



OG&E SMART STUDY TOGETHER IMPACT RESULTS

DRAFT Preliminary Summer 2010 Report

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Global Energy Partners Project Manager
C Williamson



Global Energy Partners
500 Ygnacio Valley Road, Suite 450
Walnut Creek, CA 94596

P: 925.482.2000
F: 925.284.3147
E: gephq@gepllc.com

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This report was prepared by

Global Energy Partners, LLC
500 Ygnacio Valley Blvd., Suite 450
Walnut Creek, CA 94596

Principal Investigator(s):

C Williamson
J Shishido
K Marrin

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EXECUTIVE SUMMARY

The primary goal of OG&E's Smart Study TOGETHER is to assess the impact of multiple levels of enabling technology combined with different dynamic pricing rates on a customer's energy consumption. To achieve this goal and enable effective and efficient targeting, a randomized sample of approximately 2,816 residential participant and control group customers and 465 small business (general service) participant customers in the area of Norman, OK was selected in the spring and early summer of 2010. The ultimate goal is to determine if the demand reductions achieved through a combination of price response programs, in-home technology, and energy awareness will allow OG&E to delay capital investments in incremental generation resources. Specifically, the goal is for the eventual full deployment of the program, which includes customer participation in Price Response programs enabled by Smart Meter technology, to have the effect of reducing peak demand to the extent that OG&E can avoid building a new 165 MW peaking unit in 2015 and a second 165 MW peaking unit in 2016.

This report focuses on the residential study results for the summer of 2010. Because of the limited number of small business customers in Norman and the challenges around recruiting enough participants, the small business results are to be considered more anecdotal in nature.

Residential customers were offered two rates as part of the Smart Study TOGETHER project. Based on their random assignment, participants were offered either a Variable Peak Pricing rate with a Critical Price option (VPP-CP) or a Time-of-Use rate with a Critical Price option (TOU-CP). Customers in the control group were left on their existing standard rates. OG&E is testing four technology options, including a web portal, an in-home display (IHD), a programmable communicating thermostat (PCT), and a combination of all three.

A randomized study design was implemented with participant and control groups to estimate the load reduction associated with each of the eight rate-technology combinations. The design was expanded to give secondary information about load reduction for three age and three income demographic segments. Customers were then recruited to participate in the study, and data were collected over the summer of 2010. 2,546 customers were included in the analysis.

This report provides summary information about the results of the study, with load reductions in tabular and graphical form accompanied by comments. Some results by age and income are included in this report as well. More complete results are included in the Appendices. Highlights of the findings include:

- In general, the automated response of the PCT and All Three groups reduce load more than the information provided through the IHD and Web Portal. However, the IHD and Web Portal load reductions are more constant throughout the peak period, whereas the PCT and All Three groups tend to have a load reduction spike at the beginning, and savings that decay later in the period.
- The TOU-CP shows significant load reductions for all technology groups on both non-event weekdays and the weekday event.
- The VPP-CP rate shows load reductions that correspond to the price level on weekdays – there is statistically significant load reduction on days when prices are standard, medium, and high, and the load reduction increases as the price increases.
- The one weekend event was on a late summer day, and as a result, the savings were smaller but still statistically significant.
- The one weekday event was on a mild day as well. The kW savings for the TOU-CP were comparable to the average weekday, but because the load was lower, the percentage

savings were higher. The behavior of the VPP-CP customers was similar to their behavior on a high-priced day, but with less load reduction since the load for the day was lower because of the temperature.

- The PCT groups often show more savings than the All Three group, but this is likely due to the fact that the PCT group included only those with central AC, and the All Three group included customers both with and without central AC.
- In several cases, the All Three group showed both overall load reductions throughout the day and further reductions in the peak period. This suggests that the information technologies (IHD and Web) are prompting behavioral changes in addition to the automated response of the PCT.

Findings related to the Age segments include:

- The Family age segment has the highest average baseline usage, and generally has higher load reductions, particularly for the PCT and All Three groups.
- In several cases, the Mature and Young groups showed better load response than the Family group to the information provided by the IHD.
- The PCT and All Three groups generally had higher savings for each of the age segments, consistent with the trend for the combined population.

Findings related to the Income segments include:

- The High income segment has the highest average baseline usage, and generally has higher load reductions.
- The Low income segment shows higher percentage savings in many cases, and in some cases higher kW savings than the higher-consuming Middle and High income segments. This may be a result of Low income customers being more price sensitive and taking more actions to reduce load.
- The PCT and All Three groups in the Low income segment appear to have load reductions throughout the day, including several hours before the event. Since these are off-peak periods, this is not price response, but may be due to the PCTs replacing manual thermostats, then being used to reduce load when the home is unoccupied. It could also be due to higher energy awareness.

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BACKGROUND

1.1 GOALS OF THE STUDY

The primary goal of OG&E's Smart Study TOGETHER is to assess the impact of multiple levels of enabling technology combined with different dynamic pricing rates on a customer's energy consumption. To achieve this goal and enable effective and efficient targeting, a randomized sample of approximately 2,816 residential participant and control group customers and 465 small business (general service) participant customers in the area of Norman, OK was selected in the spring and early summer of 2010. The ultimate goal is to determine if the demand reductions achieved through a combination of price response programs, in-home technology, and energy awareness will allow OG&E to delay capital investments in incremental generation resources. Specifically, the goal is for the eventual full deployment of the program, which includes customer participation in Price Response programs enabled by Smart Meter technology, to have the effect of reducing peak demand to the extent that OG&E can avoid building a new 165 MW peaking unit in 2015 and a second 165 MW peaking unit in 2016. These numbers are based on achieving a 20% customer Price Response participation rate and an average peak demand reduction of 1.3 kW per participating residential customer.

The experiment is to determine the load reduction enabled by smart grid/smart metering resulting from various combinations of dynamic rates and enabling technologies. OG&E is testing two rates, a variable peak price (VPP-CP) and a time-of-use critical peak price (TOU-CP) (for both residential and small commercial), and four technology options, including web portal, in-home display (IHD), programmable communicating thermostat (PCT), and a combination of all three. While estimating the average on-peak period load reduction is the most important goal of the study, we also plan to estimate how much load has shifted to the off-peak period, and if there is an overall reduction in energy consumption.

This report focuses on the residential study results for the summer of 2010. Because of the limited number of small business customers in Norman and the challenges around recruiting enough participants, the small business results are to be considered more anecdotal in nature.

1.2 GUIDING PRINCIPLES

OG&E established ten guiding principles for the study. These principles were used throughout the planning, design, implementation, and analysis for the program.

- Demand Response (DR) results will be obtained through customer empowerment.
- OG&E will not utilize any direct control of customer equipment or appliances.
- Customers will be provided time differentiated pricing and be allowed to choose their balance of cost versus comfort.
- Pricing (rates) will reflect true market prices minimizing any subsidies within or across customer rate classes.
- It is anticipated that all future customer participation will be voluntary, thus participation in this research will also be voluntary.
- Enabling technology will be provided to customer at no cost.
- Customers will be encouraged to remain on the program for the entire length of the study and incentives may be required.
- A control group will be utilized to eliminate the impact of weather, economic conditions, fuel prices, and other non-controllable variables.

- The number of customers participating in both the study and the control group must be large enough to provide statistically significant results which can be applied to OG&E's entire customer base.
- The sample will reflect the demographic makeup of OG&E's customer population.

1.3 RATE OPTIONS

Residential customers were offered two rates as part of the Smart Study TOGETHER project. Based on their random assignment, participants were offered either a Variable Peak Pricing rate with a Critical Price option (VPP-CP) or a Time-of-Use rate with a Critical Price option (TOU-CP). Customers in the control group were left on their existing standard rates.

1.3.1 Variable Peak Pricing

The VPP-CP was designed using the existing Residential TOU rate as a base rate. The peak period price in the TOU rate is replaced with a variable price signal sent to participating customers. A single price will apply to the entire five-hour window each day. There are four defined price levels – Low, Standard, Medium and High – to simplify communications of price level. The prices assigned to each price level are based on the underlying Standard and TOU tariffs. Low prices equate to the Off-peak energy prices, Standard to the standard tariff summer season tail-block price and Medium and High prices reflect the peak period energy prices.

The VPP-CP will also include a Critical Price, or Price Overcall Provision which can be utilized when OG&E requires a reduction in total system load. With a minimum of two hours notice, a price overcall can be issued to raise the price level to the critical price, which for VPP-CP is the same as the high price. A price overcall may occur at any time during the year. The price overcall time period will not be less than two hours nor will it exceed 8 hours in length.

The Day-Ahead On-Peak Prices for VPP-CP are communicated to the customer by 5:00 PM on the day prior to the applicable day. On-Peak Hours are from June 1 through September 30, beginning each day at 2:00 PM and ending at 7:00 PM, local time, excluding Saturdays, Sundays, Independence Day (as observed) and Labor Day. Off-Peak hours are defined as all hours that are not On-Peak hours. Table 1-1 shows the prices for the VPP-CP rate.

Table 1-1 VPP-CP Prices

Price Level	VPP-CP Price	Estimated Days at each price level
Low and off-peak	4.5¢ per kWh	55
Standard	11.3¢ per kWh	39
Medium	23.0¢ per kWh	17
High	46.0¢ per kWh	9
Critical	46.0¢ per kWh	

1.3.2 Time-of-Use with Critical Pricing

The TOU-CP uses the existing Residential and General Service TOU rates as the respective base rate. The TOU-CP will also include a Critical Price, or Price Overcall Provision which can be utilized when OG&E requires a reduction in total system load. With a minimum of two hours notice, a price overcall can be issued to raise the price level to the critical price. A price overcall may occur at any time during the year. The price overcall time period will not be less than two hours nor will it exceed 8 hours in length.

Table 1-2 shows the prices for the TOU-CP rate.

Table 1-2 TOU-CP Prices

Price Level	R-TOU-CP Price
Off-peak	4.5¢ per kWh
On-Peak	23¢ per kWh
Critical	46.0¢ per kWh

1.4 TECHNOLOGY OPTIONS

OG&E is testing four technology options:

- Web portal
- In-home display (IHD)
- Programmable communicating thermostat (PCT)
- Combination of all three.

To determine the most appropriate equipment for each technology, OG&E turned to the focus groups they conducted along with GE during May 2008. Customers felt that Smart Grid enabled tools give them more control over their consumption and costs. They also felt having more information allows them to make better choices. Customers were more interested in an in-home device over a PCT, but expressed concern over the costs. Consumers also expressed interest in having online access to their consumption so they could more actively manage their consumption. Because the costs and benefits associated with each technology vary, OG&E decided to include each equipment configuration in the Study. Furthermore, because cost was more than twice as important to consumers as any other attribute, OG&E will also be providing the equipment at no cost to the customer.

Customers that choose to participate in Smart Study TOGETHER will randomly be assigned to one of the above technology configurations or to the control group.

EXPERIMENTAL DESIGN

2.1 STUDY DESIGN

For the Residential study, we collected interval data using smart meters from a sample of customers in Norman to estimate the load reduction resulting from various combinations of dynamic rates and enabling technologies. The two rates and four technology options described above result in eight combinations (referred to as treatments), with a separate sample of participating customers needed for each. For the analysis, we also need a control group of customers who are as similar as possible to those in each of the treatment (rate-technology combination) group. We estimate the load reduction by comparing the load for the customers with each rate-technology combination with the load for customers in the control group. We make this comparison for several different day types, including average weekend days, average weekdays, event days, and average days for the various price levels for the VPP-CP rate. In addition to a direct comparison, we intend to use a statistical regression model, which will quantify the variability from all other known sources (appliances, building size, etc.) and remove that from the estimate of load impact. It will also allow us to estimate the load impact for different temperatures, which we expect will vary, and different appliance mixes. However, the analysis for this report is based on a direct comparison of loads.

One important consideration was how to assign customers to the different rate-technology options and the control group. Because OG&E is planning to offer dynamic rates on a voluntary basis, it was most appropriate to recruit customers to volunteer to participate. However, since OG&E needs to determine the best option for rate and technology implementation, it was appropriate to randomize the assignment of customers to the 8 treatment cells. This allows for direct and unbiased comparison of the rate-technology options. If customers were given a choice, then the results for, say, the IHD group would not apply to all customers, but only to those customers who would choose an IHD when the program is implemented. Also, it was critical to assign customers who volunteer randomly to the control group as well. This may seem strange, but the control group should include customers who are as much “like” those in the treatment groups as possible. It was made clear to these customers that they were not on the rate, and will not receive any technology. Because the control group was to be compared with all eight of the treatment groups separately, we decided to double its sample size to improve the precision of all estimates.

Two of the technologies, IHD and Web Portal, require specific customer qualifications. If a customer does not have central AC, they cannot be assigned to PCT. If a customer does not have internet access, they cannot be assigned to Web Portal. Because of this, all customers assigned to either of these groups also were given a secondary assignment. During the initial contact, if a customer assigned to PCT reported that they did not central AC, then they were given their secondary assignment. If a customer assigned to Web Portal reported that they did not have internet access, then they were given their secondary assignment. This was asked before they were offered anything, so the customers never know if they were receiving their original assignment or their secondary assignment. We considered the same approach for the All Three technology group, but chose not to implement it. If in an eventual system-wide rollout, all three technologies were offered to all customers, there would be a mix of customers with and without central AC and with and without internet access. In those cases, the customers would receive those technologies which they qualified for, so we decided to emulate that with the study. So the load reductions for the All Three category reflect a mix of customers, most of which have all three, but some of which have only two, or in some cases, only one of the three. But this reflects what we would expect in a future rollout.

2.2 DEMOGRAPHICS

The residential sample design includes additional layers, based on customer demographics of two types. Estimating the load impacts for each rate-technology combination is still the primary goal, but we also wanted to get a sense of how the impacts vary across three life stage demographic groups (Young, Family, and Mature) and three income demographic groups (Low, Medium, and High), based on PRIZM codes. Including the demographics will help OG&E better understand what types of customers provide the most load reduction, and will help determine marketing approaches for future recruiting efforts. The sample design estimates the top level (rate-technology group) at one precision, and the life stage and income groups with less precision. But the design is nested, so the layers build up to the top level, giving us the best estimate for the rate-technology groups.

2.3 RANDOMIZATION

In order to implement a randomized design, all eligible customers were randomly preassigned to either one of the treatment groups or the control group. This was done before recruiting started, so that then when customers called in or went online to join the study, the assignment was already determined. In order to optimize survey data collection and ensure consistent data, each interested customer first responded to a survey, and then was either told what their preassigned rate technology combination was, or if they were in the control group, they were told that they were not eligible to participate this year. As a result, we had survey data for all customers, both participant and control.

The sample design called for 10% of the sample in each of the eight rate-technology cells, and 20% in the control group. In the randomization process, we assigned slightly more customers (10.5%) in each rate-technology group, and slightly fewer (16%) in the control group. This was done because we expected that some participants would not be able to participate because of equipment incompatibility, which would not happen with the control group.

2.4 LACK OF PRETREATMENT DATA

Because the meters were installed in the spring and early summer of 2010, the analysis of summer 2010 did not allow for the use of any pretreatment data. In a designed statistical experiment of this type, having data for both before the rate and technology start and after they are in place allows adjustment of the results for any pre-treatment differences between the participant and control groups. This was not possible with this study, since there was not interval data available for the study customers before the smart meters were installed. This made the randomized assignments to treatment and control even more important, since randomization is an effective way to ensure that pretreatment differences are minimized and groups of customers are similar.

IMPLEMENTATION

3.1 RECRUITING

Recruiting started early in 2010, and as of June 30, 2010, there were 2,667 residential customers recruited for the study, summarized in Table 3-1 below. This table reflects the rate-technology options that were used for recruiting, and all the customers that were recruited.

Table 3-1 Smart Study TOGETHER 2010 Recruiting

	Control	TOU-CP	VPP-CP	Total
Control	597	-	-	597
Web Portal	-	270	277	547
IHD	-	266	250	516
PCT	-	245	239	484
All Three	-	266	257	523
Total	597	1,047	1,023	2,667

3.2 RERANDOMIZATION

The sample design called for consistent sample sizes across all cells, both at the rate-technology level, and at the demographic level. Because different types of customers signed up at different rates, because there was random variation in how many signed up, and because there were more customers who were disqualified based on some equipment considerations, certain of the cells filled up more quickly than others. We capped the cells to avoid oversubscribing customers, resulting in some customers that wanted to participate not being included in the study. These customers were told that they would be eligible to participate the next summer. For certain cases where some cells filled up more quickly than others for the same demographic segment, we changed the random preassignments for customers *who had not yet contacted OG&E* from the cell that was full to others that were not. Because we did this only for those who had not yet tried to sign up, the randomized design was retained, but we were able to fill up more of the cells.

In the end, we did not fill all the cells to the target levels. The load shapes for those cells with fewer customers were not as precisely estimated as those with larger samples, but we did get a sufficient sample in each for valid statistical analysis.

3.3 DIFFERENCES BETWEEN ASSIGNMENTS AND ACTUAL INSTALLATIONS

One implementation issue had to do with assigned technologies not matching installed technologies in some cases. During recruiting, as described above, each residential customer was assigned to either the control group or to one of the eight rate-technology groups, either based on their primary assignment or their secondary assignment.

In every case, the rate and control group assignments were done correctly. None of the control group customers had a technology installed, and all were identified as control. We randomized the technology assignments as described above, and then Converge handled the recruiting and installation. As the installations were occurring, OG&E tracked the customer installation status based on the assigned rate and technology group. At the end of the summer, when we

examined the database containing variables indicating whether access to the web portal was provided and indicating the number of IHD and PCT devices installed. We used these variables to determine the actual installed technologies. Unfortunately, the information about whether the primary assignment or the secondary assignment was used was not retained in the database.

Looking at the data, we realized that not all installations had occurred as planned. All installations should have only been for only one or for all three of the technologies, except for control group customers which received none. Most customers either received their primary or secondary assignments, but some customers received something other than what should have been installed. Some customers, for example, had two technologies installed, which, based on the technology assignments, should have not occurred, except as part of an all three assignment in special circumstances. Those customers assigned to all three that did not have central AC would only have IHD and Web Portal, and those without internet access would have only IHD and PCT. Because we wanted to include all records that were valid, we checked to see if there was a possible valid reason for having these unusual technology combinations, and if there were, we included the customer. For example, if a customer's survey response indicated no central AC, was assigned to the All group, and only had Web and IHD installed, they were assumed to be correctly assigned into the All group. This is appropriate, since the field staff would not have been able to install a PCT without central AC.

One two-technology combination that should never have occurred was Web Portal and PCT, since there was no circumstance under which an IHD device should not have been installed. We excluded these customers from the analysis. In other cases we used our best judgment to categorize customers, often making ex-post assumptions about internet access based on the actual installations, since access to the internet was not included in the database. Furthermore, we found that some customers had no technologies installed even though they were assigned to a rate-technology category. These customers were placed into a newly-created Rate Only group. We believed that the majority of the Rate Only group customers were those who agreed to participate, but for whom OG&E was unable to set up an appointment to install equipment (either IHD or PCT). This group was excluded from the analysis, mainly because their self-selected nature meant that they were not matched to the control group.

We made an effort to keep as many customers in the analysis as possible, based on the assumption that the differences between assigned and installed technologies were random installation errors and that there were no systematic reasons that customers did not receive the technology they were supposed to have received. As a result, we decided that there was more value to using the customers "as installed" in those cases where the installation was incompatible with the original assignment, subject to categorizing them into one of the four technology groups. Further detail regarding technology group categorization can be found in the Appendix A. The following Table 3-2, which excludes the control group customers, displays technology assignments as well as the actual installed technologies for all customers with interval data used in the analysis. The totals for assigned technology differ from the recruited sample given above because there were some additional recruits that came in after 6/30/2010 and there were a few incompatible technology combinations.

Table 3-2 Smart Study TOGETHER 2010 Assigned versus Actual

Actual Technology	Assigned Technology				
	Web Portal	IHD	PCT	All Three	Total
Web Portal	540	1	5	40	586
IHD	2	493	17	0	512
PCT	1	0	398	0	399
All Three	0	0	1	489	490

No Technology	23	44	149	12	228
Total	566	538	570	541	2,215

3.4 SAMPLE SIZES USED FOR ANALYSIS

Using the actual technology assignments as described above, Table 3-3 shows the number of customers in each rate-technology group that were used in the analysis.

Table 3-3 *Smart Study TOGETHER 2010 Sample Sizes Used*

	Control	TOU-CP	VPP-CP	Total
Control	559	-	-	559
Web Portal	-	286	300	586
IHD	-	253	259	512
PCT	-	192	207	399
All Three	-	240	250	490
Total	559	971	1,016	2,546

RESULTS

Using the interval data collected for customers in the study, along with the actual assignments described above, the savings for each day type were estimated as follows. We first calculated the average hourly load for each day type for each customer. Since these were based on actual measured data for the days, these were not statistical estimates and so had no uncertainty associated with them. Then for each rate-technology combination and for the control group, we calculated an average day type load shape for each demographic combination segment (age and income), and then weighted those segments based on the OG&E service territory proportions in each segment. This adjusted the relative representation of the different demographic segments to correspond to OG&E's service territory instead of to the roughly equivalent sample sizes from the sample design. We also calculated the associated variances and 90% confidence intervals for these estimates. The participant and control group load shapes in the graphs in this section are the result of these calculations.

We then calculated the savings as the difference between the control group load and the participant group load for each day type, for each rate-technology combination. We used the variances of the load shape estimates to calculate the 90% confidence intervals for the savings as well.

4.1 OVERALL RESULTS BY RATE AND TECHNOLOGY

This section presents the results for the entire rate-technology group, including all demographic segments. As described above, the demographic segments are weighted to reflect the overall mix of customers in OG&E's service territory.

4.1.1 Average Non-Event Day Impacts

We start with the impacts on non-event days. Table 4-1 below shows the baseline on-peak consumption (from the control group) and the kWh and percent savings for each day type and each rate-technology combination, as well as the average and peak kW savings. Note that the peak kW savings is the highest savings during the peak period, usually at the beginning of the period, and not necessarily coincident with OG&E's peak.

Table 4-1 **Average Customer On-Peak Savings: Hour 15 - Hour 19**

	Baseline kWh Usage	kWh Savings	% Savings	Average kW Reduction	Peak kW Reduction
TOU-CP Non-Event Weekend					
PCT Only	16.76	0.28	1.67%	0.06	0.10
IHD Only	16.76	1.37	8.17%	0.27	0.35
All	16.76	0.57	3.43%	0.11	0.16
Web Only	16.76	0.44	2.63%	0.09	0.16
TOU-CP Non-Event Weekday					
PCT Only	14.85	4.43	29.87%	0.89	1.26
IHD Only	14.85	2.45	16.47%	0.49	0.52

All	14.85	3.89	26.21%	0.78	1.11
Web Only	14.85	1.61	10.86%	0.32	0.35
VPP-CP Low Weekend					
PCT Only	16.76	-0.12	-0.71%	-0.02	0.06
IHD Only	16.76	0.35	2.11%	0.07	0.14
All	16.76	0.27	1.60%	0.05	0.09
Web Only	16.76	0.62	3.67%	0.12	0.19
VPP-CP Low Weekday					
PCT Only	11.60	1.28	11.07%	0.26	0.34
IHD Only	11.60	1.29	11.13%	0.26	0.29
All	11.60	1.43	12.36%	0.29	0.34
Web Only	11.60	1.52	13.07%	0.30	0.33
VPP-CP Standard					
PCT Only	14.09	3.08	21.85%	0.62	1.07
IHD Only	14.09	0.89	6.28%	0.18	0.19
All	14.09	2.84	20.18%	0.57	0.93
Web Only	14.09	1.07	7.59%	0.21	0.25
VPP-CP Medium					
PCT Only	17.13	5.01	29.24%	1.00	1.64
IHD Only	17.13	1.38	8.04%	0.28	0.29
All	17.13	4.39	25.63%	0.88	1.38
Web Only	17.13	1.41	8.26%	0.28	0.32
VPP-CP High					
PCT Only	18.37	5.98	32.55%	1.20	1.92
IHD Only	18.37	1.96	10.65%	0.39	0.45
All	18.37	5.20	28.29%	1.04	1.63
Web Only	18.37	2.16	11.76%	0.43	0.51

For the TOU-CP group, there is very little change on weekend days, with only the IHD group showing a statistically significant difference during a few afternoon hours. The load reductions during the weekdays, however, are all statistically significant, with the PCT and All Three groups showing the greatest reduction. Note that for these two groups, the average and peak kW savings are quite different, indicating that the savings are not flat throughout the peak period, which can be seen clearly in the graphs below.

The savings estimates for the VPP-CP group across the different day types reflect both the differences in price effect and the differences in the days at the various price levels. The level of VPP weekday price, be it low, standard, medium, or high, is set based on the forecasted OG&E system load, which is driven primarily by temperature. So higher prices are generally driven by higher system loads. Fortunately, the higher the usage, the higher potential savings, so that as the price goes up, the savings potential increases as well.

The nature of the savings of the VPP-CP rate is similar to the TOU-CP rate, with the PCT and All Three groups saving more than the IHD and Web groups on all but the low-priced days.

One important consideration to keep in mind is that the PCT group includes only those customers with central AC, since that was a requirement of having the PCT. For the All Three group, there were many with central AC, but some without, since that group represents a more diverse population. Because of this, the savings for the PCT group are often slightly higher than the savings for the All Three group. We believe that this is a result of the differences in the mix of customers, and does not reflect a fundamental difference between how customers are responding.

The graphs below show the estimated load shapes for the control group and for each of the rate-technology groups for each day type for each rate. These graphs allow for a comparison of the different groups. We start with the TOU-CP rate group.

Figure 4-1 below shows the load shapes for the TOU-CP rate for an average of the non-event weekend days. On weekend days, the TOU-CP rate appears not to have any real effect on usage. The IHD Only group appears slightly (though not statistically significantly) lower, probably due to the increased awareness IHD customers have of their energy use. Note that prices for the TOU-CP customers are lower on weekends than the standard rate, but this lower price does not result in an increase in energy use.

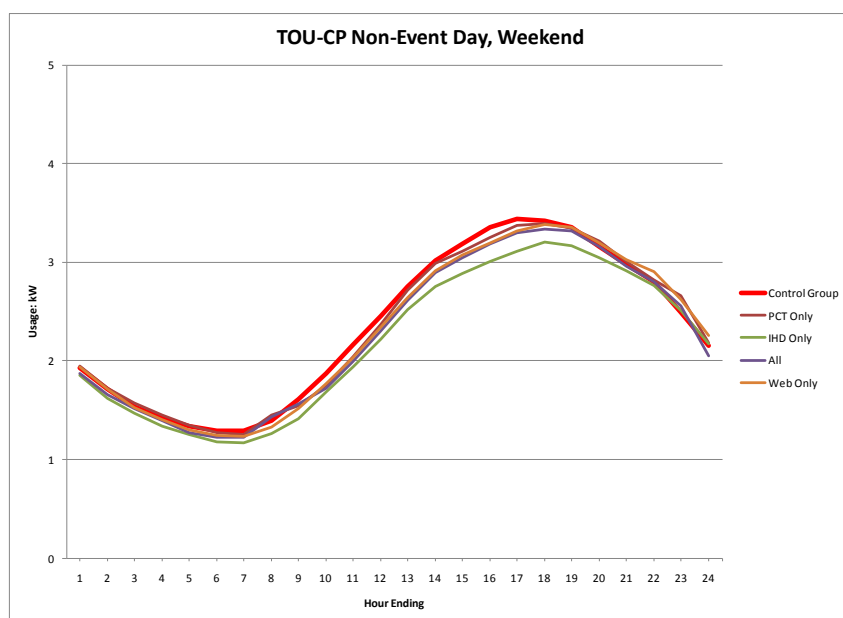


Figure 4-1 *TOU-CP non-event weekend day, all rate-technology combinations*

Figure 4-2 shows the load shapes for the average non-event weekday. The PCT and All Three groups clearly show a bigger initial savings, when the PCTs raise their setpoints in response to the higher price, but that savings decays of the time of the event, since the indoor temperature rises to the new setpoint, and the central AC goes on again. The IHD and Web only groups are fairly similar, with the IHD showing slightly more savings, which may be due to increased awareness of energy use, though it is not statistically significant.

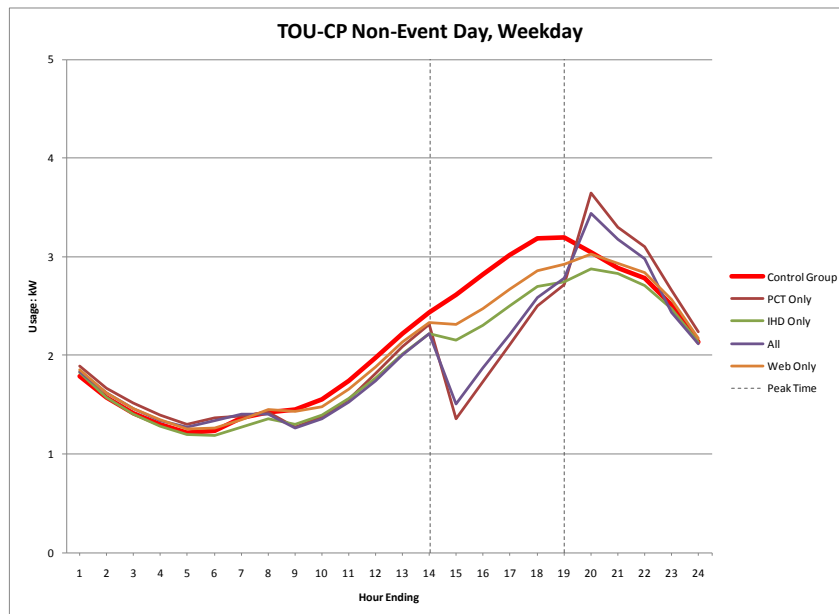


Figure 4-2 TOU-CP non-event weekday, all rate-technology combinations

Figure 4-3 below shows the load shape for the VPP-CP group for an average weekend day. There are not any significant differences between the load shapes for the control group and any of the rate-technology groups.

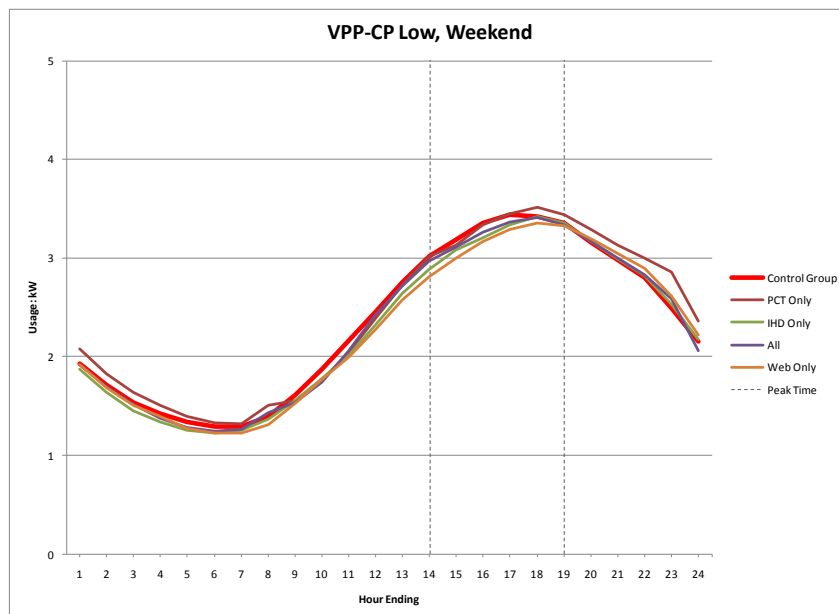


Figure 4-3 VPP-CP non-event weekend day, all rate-technology combinations

Figure 4-4 shows the load shapes for the VPP-CP rate on low-priced weekdays. Note that even though the price during the peak period does not change, there appears to be a load reduction for all rate-technology groups both early in the day and to a lesser extent, at the beginning of the peak period. We believe that the early drop is due to increased awareness of energy use combined with PCTs, which customers appear to be using not only to preset price response, but

also to program in more conventional ways to lower the setpoint when they are out of the home during the day.

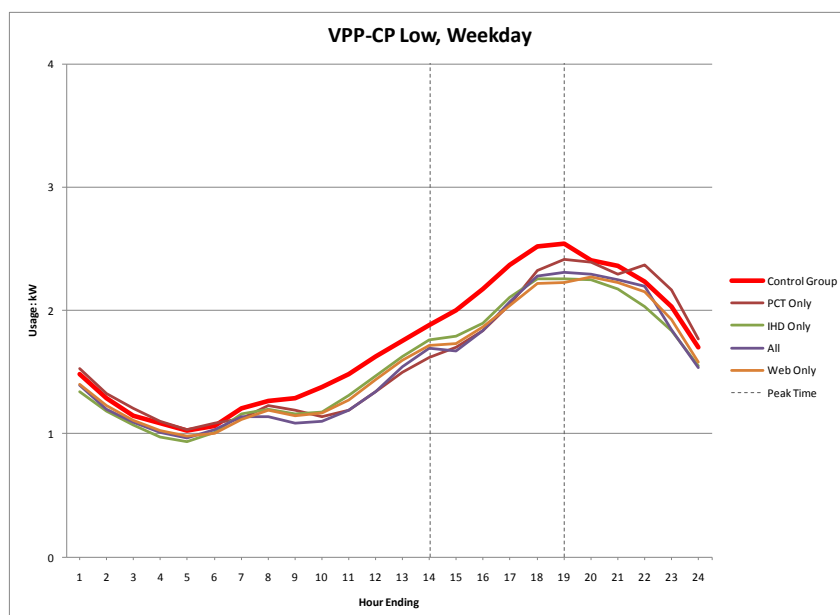


Figure 4-4 VPP-CP non-event weekday, low price, all rate-technology combinations

Figure 4-5 shows the load shapes for the VPP-CP rate on standard-priced weekdays. There is a more significant drop in the loads for the PCT and All Three groups that is in response to the price increase, and a smaller drop in the IHD and Web groups. Note that there is also a sizeable (and statistically significant) “rebound effect” after the event for both the PCT and All Three groups, when the PCTs are reset back to a lower temperature, increasing energy use. For the PCT group, this effect lingers throughout the night, with slightly higher usage until the early morning hours. There does not appear to be any rebound effect for the IHD and Web groups.

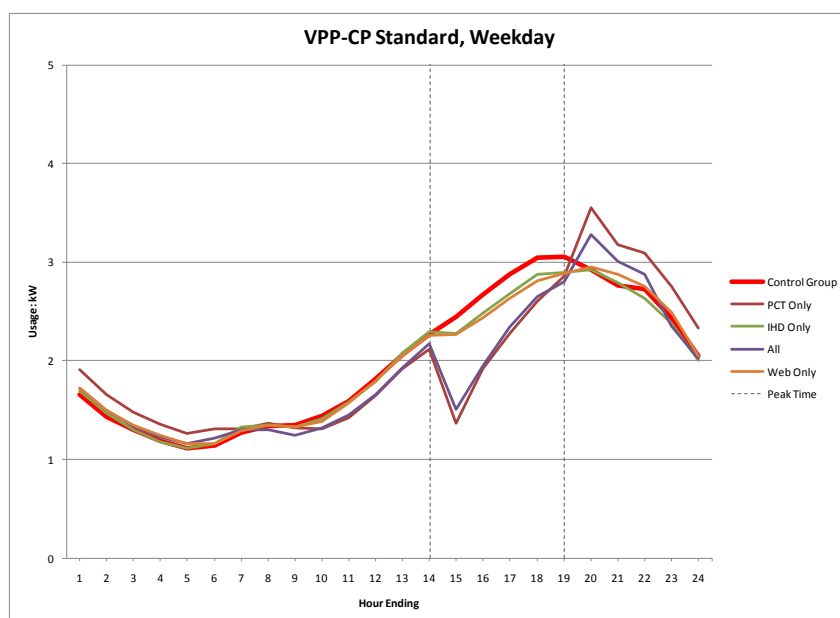


Figure 4-5 VPP-CP non-event weekday, standard price, all rate-technology combinations

Figure 4-6 shows the load shapes for the VPP-CP rate on medium-priced weekdays. The effects are similar to the standard-priced day, but with a slightly higher load, slightly higher savings, and slightly more rebound effect, driven by the combination of the higher temperatures on medium-priced days and the higher price.

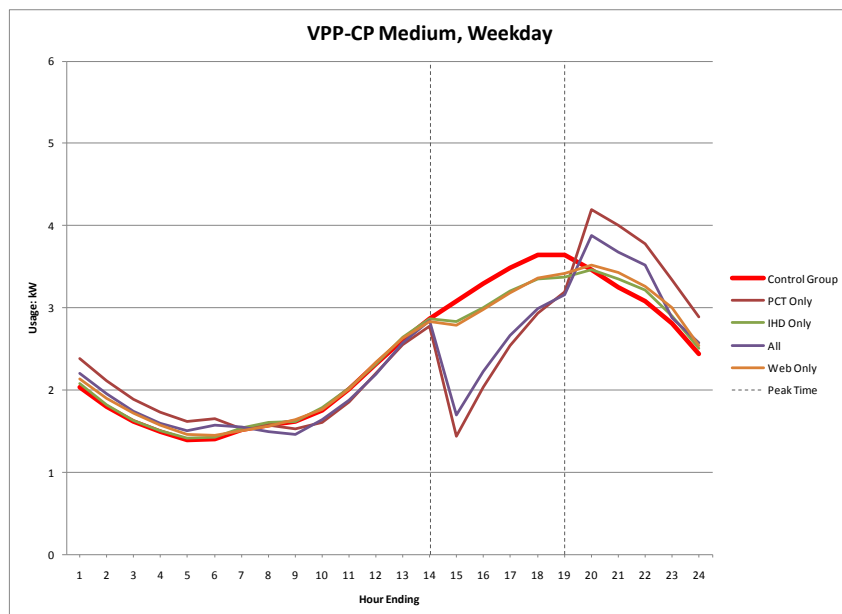


Figure 4-6 VPP-CP non-event weekday, medium price, all rate-technology combinations

Figure 4-7 shows the load shapes for the VPP-CP rate on high-priced weekdays. The patterns of increased savings over the lower prices, peak savings for the PCT and All Three groups early in the event, and a significant rebound effect continue here, with the highest savings of any non-event day for each rate-technology group.

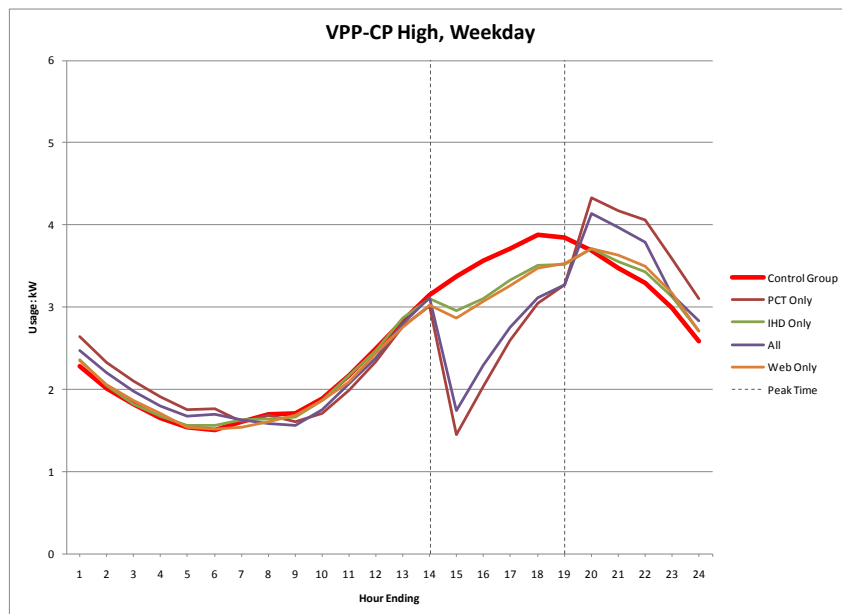


Figure 4-7 VPP-CP non-event weekday, high price, all rate-technology combinations

4.1.2 Event Day Impacts

Table 4-2 below shows the baseline on-peak consumption (from the control group) and the kWh and percent savings for the September 12 weekend day event for each rate-technology combination, as well as the average and peak kW savings. This event went from 4:00 pm to 6:00 pm. This was the only weekend day event called, and was on a late summer, early fall weekend day, so the baseline load was low, and the savings potential was minimal. The time of year, the low load, the lack of savings for PCT, and the small savings overall indicate that there was little or no cooling load during this event. This is also the only case where IHD and Web savings are generally comparable to or higher than the PCT and all, particularly for the VPP-CP rate. This is likely due to customers more likely being home on a weekend and taking manual actions beyond automated control. However, the savings across the board are small, though they are statistically significant. The savings for the two consecutive hours of the event are also fairly similar, with no big change in the level of savings from hour 17 to hour 18. This is likely due to the lack of cooling load and due to the shorter duration of the event.

Table 4-2 Weekend Day Event Day Average Customer On-Peak Savings: Hour 16 - Hour 18

	Baseline kWh Usage	kWh Savings	% Savings	Average kW Reduction	Peak kW Reduction
TOU-CP Event Weekend 9/12/10					
PCT Only	5.37	0.71	13.17%	0.35	0.43
IHD Only	5.37	0.92	17.10%	0.46	0.46
All	5.37	0.95	17.71%	0.48	0.55
Web Only	5.37	0.65	12.09%	0.32	0.40
VPP-CP Event Weekend 9/12/10					
PCT Only	5.37	0.11	2.05%	0.06	0.06
IHD Only	5.37	0.84	15.65%	0.42	0.51
All	5.37	0.18	3.42%	0.09	0.31
Web Only	5.37	0.76	14.19%	0.38	0.49

Table 4-3 below shows the baseline on-peak consumption (from the control group) and the kWh and percent savings for the August 25 weekday event for each rate-technology combination, as well as the average and peak kW savings. This was the only weekday event called, and was on a relatively mild summer day. As a result, the kW savings are comparable to the average non-event weekday for TOU-CP and for the average standard and medium price weekday for the VPP-CP. The percentage savings are higher, because of the lower base load. Also notable is that the savings are much more constant across the event, with the average and peak kW reductions very similar. This is probably more due to the relatively mild temperature, rather than the nature of the event, but without other weekday event days to compare this day with, we don't know for sure.

Table 4-3 Weekday Event Day Average Customer On-Peak Savings: Hour 15 - Hour 19

	Baseline kWh Usage	kWh Savings	% Savings	Average kW Reduction	Peak kW Reduction
TOU-CP Event Weekday 8/25/10					
PCT Only	10.80	4.21	38.95%	0.84	0.89

IHD Only	10.80	2.70	25.03%	0.54	0.59
All	10.80	3.39	31.40%	0.68	0.71
Web Only	10.80	2.15	19.95%	0.43	0.55
VPP-CP Event Weekday 8/25/10					
PCT Only	10.80	3.19	29.51%	0.64	0.80
IHD Only	10.80	1.46	13.55%	0.29	0.34
All	10.80	3.32	30.78%	0.66	0.78
Web Only	10.80	1.55	14.37%	0.31	0.38

Figure 4-8 shows the load shapes for the TOU-CP rate on the weekend event day, September 12. All four rate-technology groups showed a statistically-significant reduction in load during this two-hour event. The graph also shows the fairly flat savings, with the rate-technology lines about the same distance from the control group line for the two hours of the event.

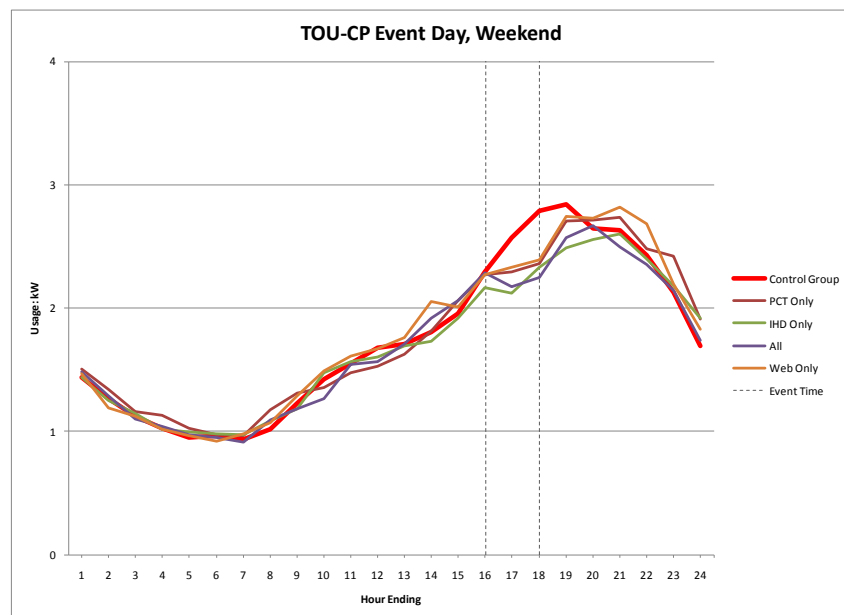


Figure 4-8 *TOU-CP weekend event day, all rate-technology combinations*

Figure 4-9 shows the load shapes for the VPP-CP rate on the weekend event day. The PCT and All Three groups show virtually no response to the event, probably because of the lack of cooling load. The IHD and Web groups do show statistically significant load reductions, with higher savings in the second hour of the event.

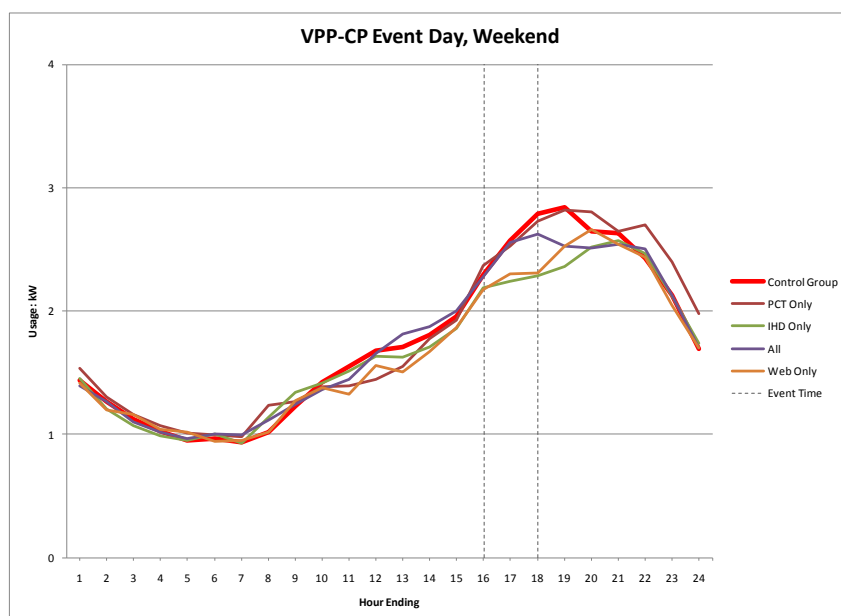


Figure 4-9 *VPP-CP weekend event day, all rate-technology combinations*

Figure 4-10 shows the load shapes for the TOU-CP rate on the weekday event day. The PCT and All Three groups show slightly higher savings, but also a much higher rebound effect than the IHD and Web groups. All the load reductions for the TOU-CP rate group on the weekday event day are statistically significant.

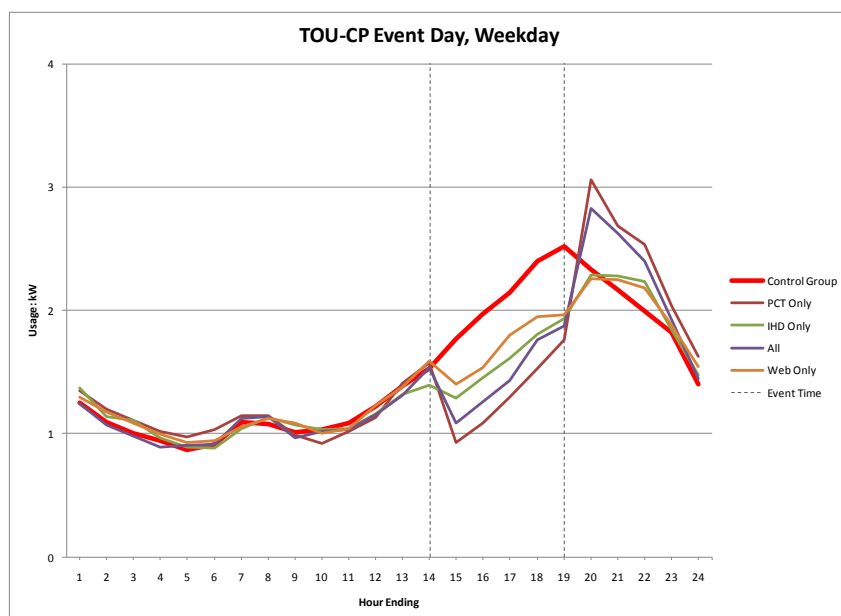


Figure 4-10 *TOU-CP weekday event day, all rate-technology combinations*

Figure 4-11 shows the load shapes for the VPP-CP rate on the weekday event day. Pattern here is very similar to the TOU-CP on the weekday event shown above, with the PCT and All Three groups show slightly higher savings, but also a much higher rebound effect. All the load reductions for the VPP-CP rate group on the weekday event day are statistically significant.

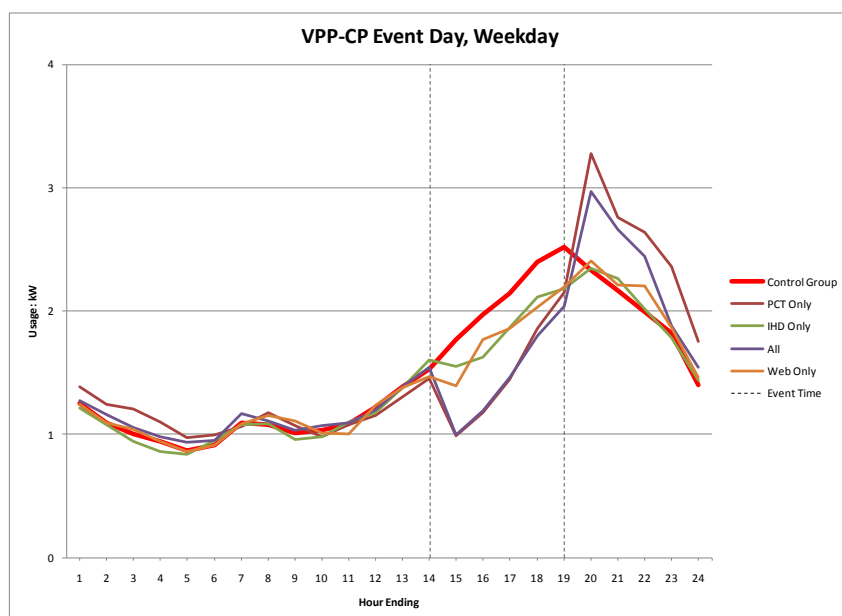


Figure 4-11 VPP-CP weekday event day, all rate-technology combinations

4.2 RESULTS BY AGE AND BY INCOME

Because the design of the study included representation of customers across three age segments and three income segments, we are able to estimate savings for each of the three levels of each demographic category. As with the overall results above, we applied weights the age categories within each income category to reflect the mix of customers in OG&E's service territory.

Similarly, we applied weights to the income categories within each age category. The resulting age and income results indicate what the expected load reductions would be if the distribution of the participants within each demographic segment were roughly similar to the distribution of the population within that segment. While it is tempting to look at combinations of age and income, such as young low income participants, this would reduce the sample sizes so much that the results would be somewhat questionable statistically.

With two rates and eleven corresponding day types, as well as four technology options, adding three age segments and three income segments creates a large volume of savings estimates. Because of this, we focus on the impacts for the weekday events for both rates, along with weekdays for TOU-CP and high-price weekdays for VPP-CP. Graphs for all day types are included in the Appendix.

One thing that we should be aware of is that with so many different combinations, random chance may result in apparent indications of effects that may not bear out in a full roll-out. That said, we can glean an idea of how different types of customers may respond to these time-varying rates and technologies by looking across all the results.

4.2.1 Impacts by Age Segment

The customers were split into three age categories, Young, Family, and Mature, based on their PRISM Codes. Each of the rate-technology groups and the control group were split up for analysis, so that each demographic segment was compared with an appropriate control group.

4.2.1.1 Impacts by Age Segment for TOU-CP

Table 4-4 below shows the savings estimates for each age group and each technology for the average non-event weekday for customers on the TOU-CP rate. With the highest baseline usage, the Family segment also has the highest load reduction for the PCT and Web groups, both on a kW and a percentage basis. The Mature has the highest savings for the IHD and All Three groups. Looking across each age segment, the PCT shows the greatest load reduction for the Family group, with the All Three saving the most for the Young and Mature groups. As with the

combined results above, this difference could be due in part to the inclusion of customers both with and without central AC in the All Three group, but only those with central AC in the PCT group.

Table 4-4 Average Customer On-Peak Savings, TOU-CP Weekday, by Age

	Baseline kWh Usage	kWh Savings	% Savings	Average kW Reduction	Peak kW Reduction
Young					
PCT Only	12.02	3.61	30.04%	0.72	1.02
IHD Only	12.02	1.24	10.35%	0.25	0.31
All	12.02	3.63	30.17%	0.73	1.05
Web Only	12.02	0.95	7.89%	0.19	0.26
Family					
PCT Only	17.12	6.68	39.03%	1.34	1.72
IHD Only	17.12	2.91	17.01%	0.58	0.63
All	17.12	3.56	20.80%	0.71	1.15
Web Only	17.12	3.77	22.02%	0.75	0.83
Mature					
PCT Only	13.98	3.65	26.13%	0.73	1.17
IHD Only	13.98	3.33	23.80%	0.67	0.70
All	13.98	4.40	31.45%	0.88	1.14
Web Only	13.98	0.73	5.24%	0.15	0.19

Figure 4-12 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the TOU-CP rate on a nonevent weekday. Note that while the Family and Mature participant loads are very similar, the control group loads are quite different, resulting in higher estimated savings for the Family segment. It appears that customers in the Family segment may be more likely to use the PCT to set the temperature higher during the entire day, not just during the peak period. This could be because the Mature segment is probably more likely home during the day, whereas homes of those in the Family segment may be unoccupied during the workday.

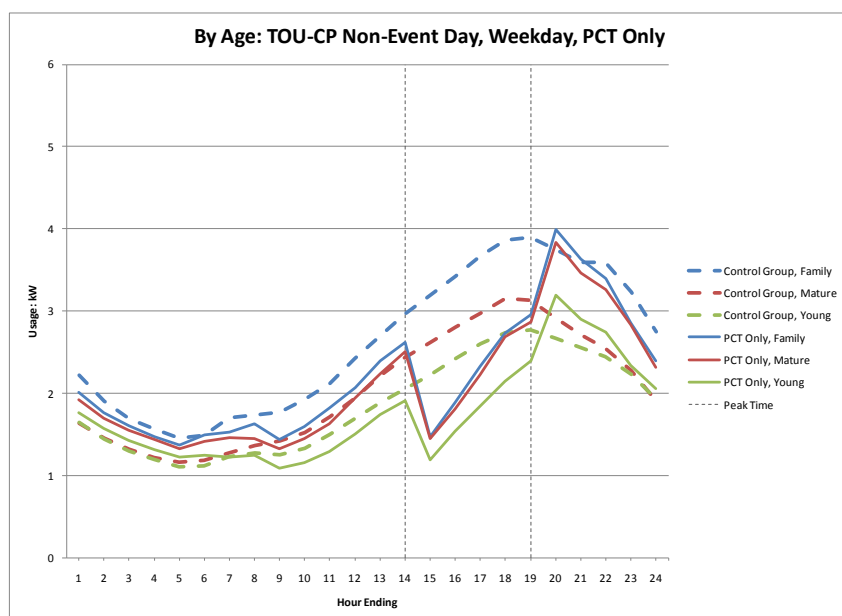


Figure 4-12 TOU-CP weekday nonevent day, PCT, by age

Figure 4-13 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the TOU-CP rate on a nonevent weekday. In this case, the Mature and Young participant loads are very similar, but the control group loads are quite different, resulting in higher estimated savings for the Mature segment. With an IHD showing the Mature customers their energy use all the time, members of this segment may be taking actions to save energy throughout the day.

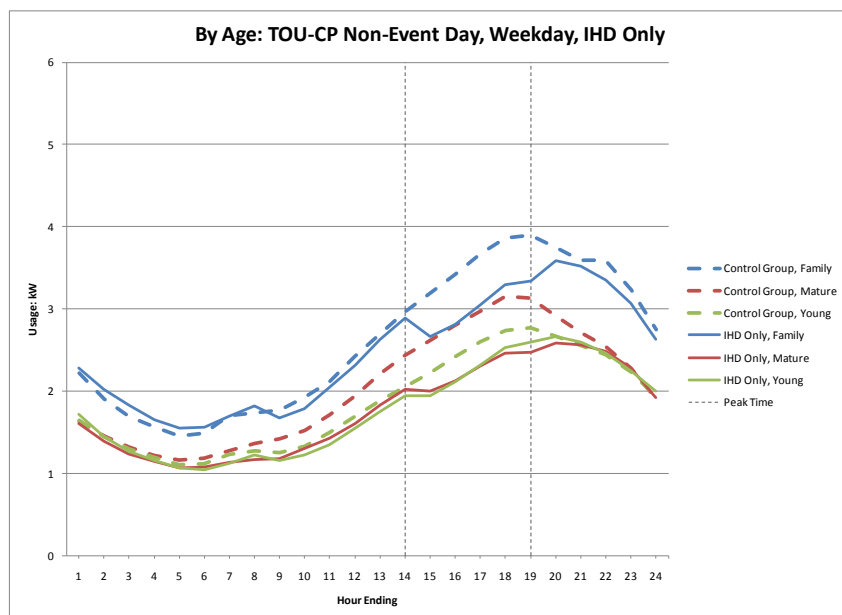


Figure 4-13 TOU-CP weekday nonevent day, IHD, by age

Figure 4-14 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the TOU-CP rate on a nonevent weekday.

The three age segments appear to be responding to the technologies in about the same way, reducing energy use somewhat throughout the entire day, but more during the peak period.

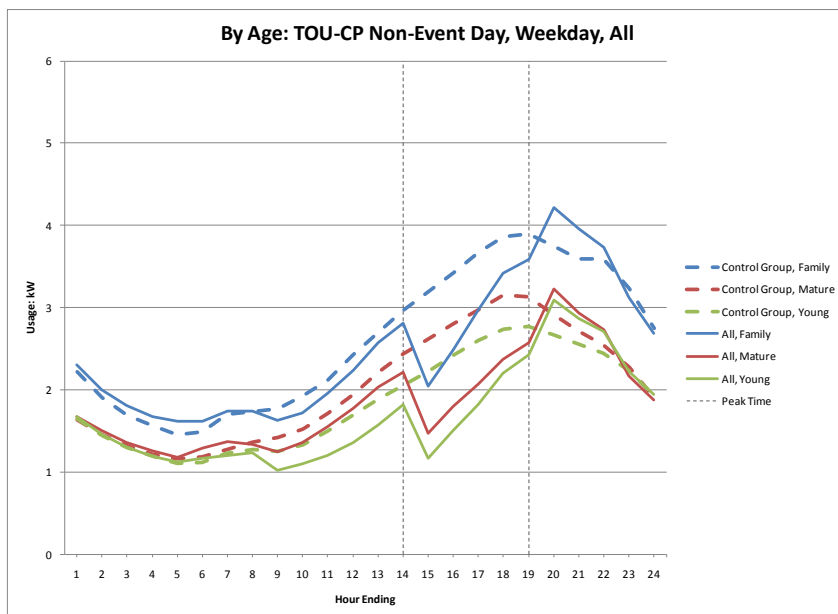


Figure 4-14 TOU-CP weekday nonevent day, All Three, by age

Figure 4-15 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the TOU-CP rate on a nonevent weekday. As with the PCT group, the Family segment appears to be reducing energy use somewhat throughout the entire day as well as during the peak period.

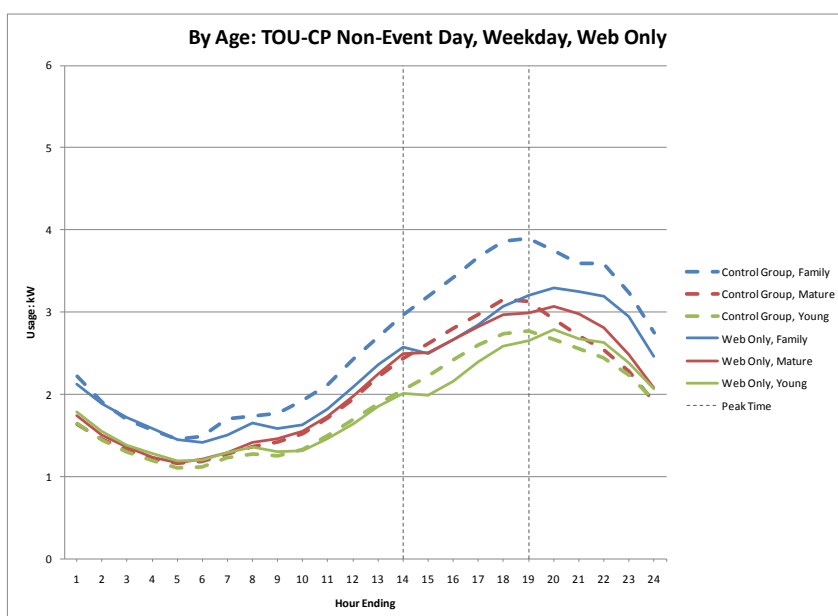


Figure 4-15 TOU-CP weekday nonevent day, Web, by age

Table 4-5 below shows the savings estimates for each age group and each technology for the weekday event of August 25 for customers on the TOU-CP rate. With the highest baseline usage, the Family segment again has the highest load reduction for the PCT and Web groups, both on a kW and a percentage basis. Again, the Mature has the highest savings for the IHD group, but unlike the non-event day, the Young group has the highest savings.

Comparing the non-event and event days for the TOU-CP is useful as well. The Family savings were higher for the non-event weekday (even though the prices were lower), indicating that most of the savings is likely due to cooling load reduction, reinforced by the high PCT savings, as opposed to behavioral changes, since the event day was a mild summer day. The Mature is mixed, with the PCT, IHD, and Web savings higher on the event day, but the All Three savings higher on the non-event day. This is more difficult to interpret, but could be due to reliance on both behavioral and automated responses, which would result in higher savings for the event day, as well as an indication of higher price sensitivity. The Young segment has higher savings for all technologies, which is probably also a combination of both price sensitivity and willingness to undergo behavioral change.

Looking across each age segment, PCT is the highest for the Mature and Family segments, and the All Three group has the highest savings for the Young segment.

Table 4-5 Average Customer On-Peak Savings, TOU-CP Event Weekday, by Age

	Baseline kWh Usage	kWh Savings	% Savings	Average kW Reduction	Peak kW Reduction
Young					
PCT Only	8.74	3.68	42.12%	0.74	0.78
IHD Only	8.74	2.32	26.58%	0.46	0.50
All	8.74	4.49	51.40%	0.90	1.04
Web Only	8.74	1.88	21.54%	0.38	0.45
Family					
PCT Only	11.39	5.29	46.46%	1.06	1.15
IHD Only	11.39	1.68	14.75%	0.34	0.56
All	11.39	2.36	20.75%	0.47	0.53
Web Only	11.39	2.81	24.64%	0.56	0.71
Mature					
PCT Only	9.77	3.95	40.49%	0.79	0.90
IHD Only	9.77	3.82	39.16%	0.76	0.85
All	9.77	3.02	30.89%	0.60	0.64
Web Only	9.77	1.96	20.06%	0.39	0.61

Figure 4-16 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the TOU-CP rate on the weekday event day. All segments respond in a similar way, with the Family segment showing the biggest savings and also the most pronounced rebound effect. It appears that customers in the Young segment reduce their load for the whole day in this case, perhaps changing their behavior in response to the previous day's notice of higher prices.

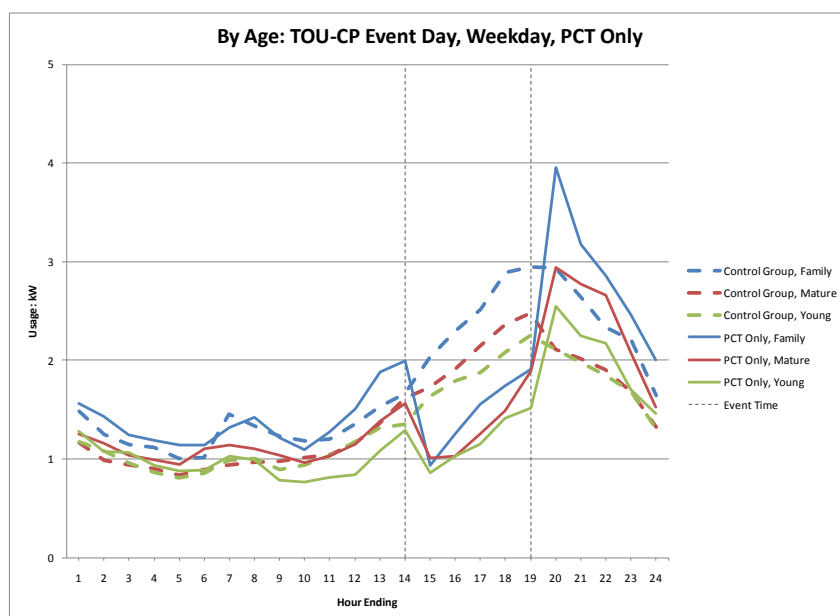


Figure 4-16 TOU-CP weekday event day, PCT, by age

Figure 4-17 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the TOU-CP rate on the weekday event day. In this case, the Mature and Young segment load shapes are fairly similar, with higher estimated savings than the Family segment. This further suggests behavioral changes in response to higher prices.

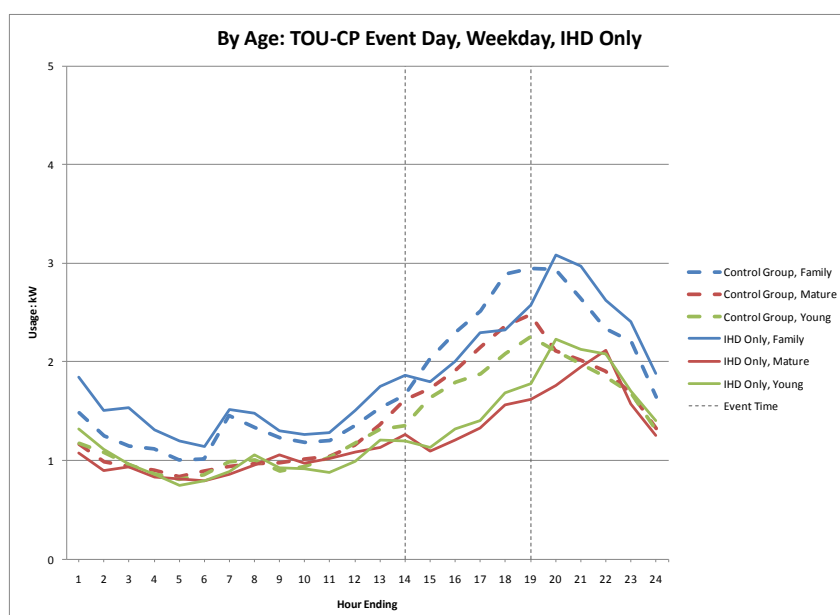


Figure 4-17 TOU-CP weekday event day, IHD, by age

Figure 4-18 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the TOU-CP rate on the weekday event day. The Family and Mature segments appear to be responding to the technologies in similar

ways, primarily during the event period. However, the Young segment load shape is particularly interesting. There are statistically significant load savings for several hours before the start of the event, probably driven by behavioral changes in response to the day-ahead notification. Then, at the start of the event, the load reduces further, probably driven by the automatic response of the PCT. This may be the clearest illustration of the effect of the combination of the three technologies in the All Three group. All segments also have a significant rebound effect after the end of the event period.

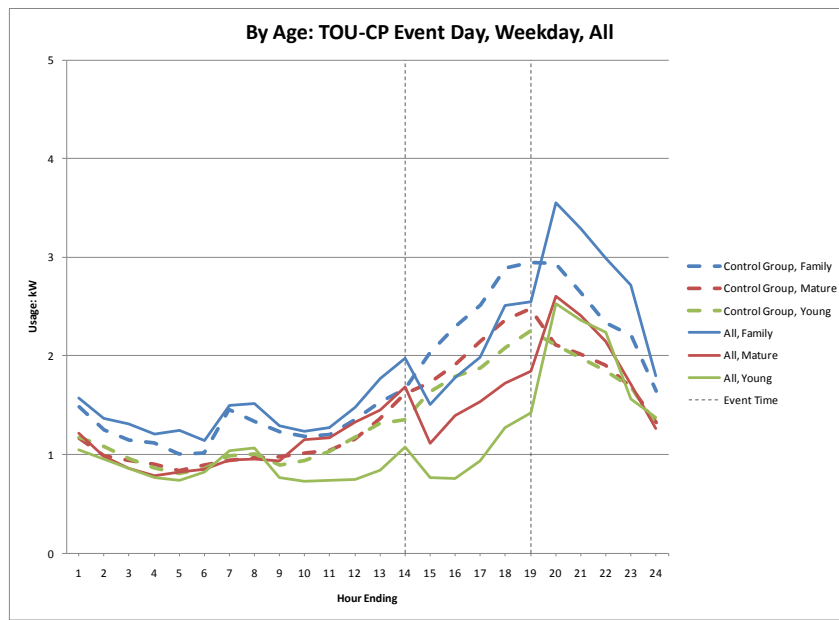


Figure 4-18 TOU-CP weekday event day, All Three, by age

Figure 4-19 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the TOU-CP rate on the weekday event day. The three age segments appear to be responding similarly during the event period, with most of the load reduction probably due to behavioral changes, given the lack of much of a rebound effect for any of the segments.

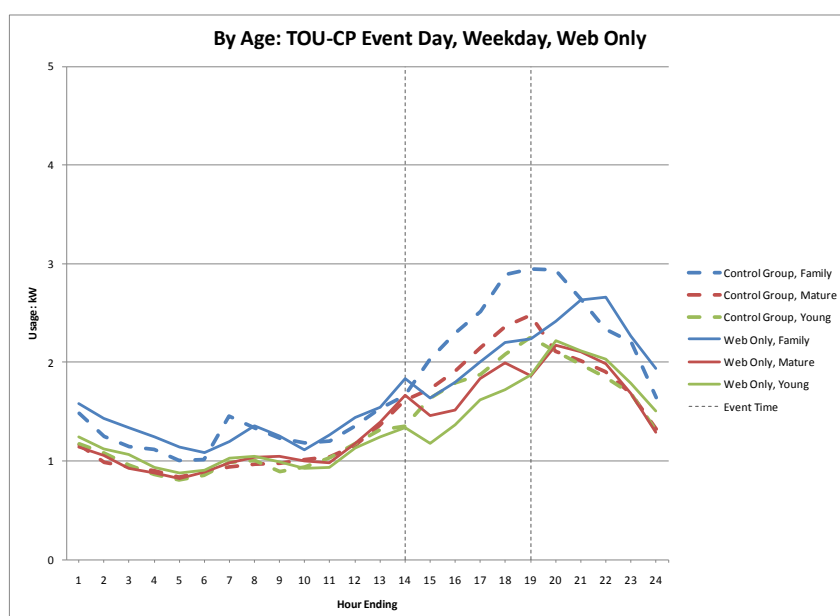


Figure 4-19 TOU-CP weekday event day, Web, by age

4.2.1.2 Impacts by Age Segment for VPP-CP

Table 4-6 below shows the savings estimates for each age group and each technology for the average non-event weekday for customers on the VPP-CP rate. With the highest baseline usage, the Family segment also has the highest kW load reduction for the IHD and Web groups. The Mature has the highest savings for the PCT, and the Young segment has the highest savings for the All Three group.

Looking across each age segment, the PCT shows the greatest load reduction for the Family and Mature segments, with the All Three saving the most for the Young segment. As with the combined results above, the higher PCT savings could be due in part to the inclusion of customers both with and without central AC in the All Three group, but only those with central AC in the PCT group.

One curious result is that for the Mature segment customers on the VPP-CP rate, those customers in the IHD and Web groups who receive only information (without the automated response of a PCT) do not respond to either the high price of an event or the high-priced weekdays. This is in stark contrast to the Mature customers in the IHD group on the TOU-CP rate, who did respond with significant load reductions on both weekdays and on the event day. This is very difficult to interpret and understand. It could be due to random chance, if this group of mature customers just happened to be less receptive to the information from an IHD for some reason. But it could also be due to some characteristic or reaction to the VPP-CP rate that is not present with the TOU-CP rate. This is conjecture, but it could be something like fatigue from so many price changes – maybe these folks had trouble keeping track of things with prices changing every day. Or maybe there was confusion about the prices. But there does seem to be something different going on here, which may warrant further research.

Table 4-6 Average Customer On-Peak Savings, VPP-CP High-Priced Weekday, by Age

	Baseline kWh Usage	kWh Savings	% Savings	Average kW Reduction	Peak kW Reduction
Young					
PCT Only	15.18	4.38	28.85%	0.88	1.51
IHD Only	15.18	2.33	15.33%	0.47	0.52

All	15.18	5.46	35.97%	1.09	1.46
Web Only	15.18	2.29	15.10%	0.46	0.53
Family					
PCT Only	20.66	6.54	31.63%	1.31	2.36
IHD Only	20.66	3.15	15.27%	0.63	0.70
All	20.66	5.02	24.31%	1.00	1.81
Web Only	20.66	3.80	18.37%	0.76	0.84
Mature					
PCT Only	18.06	7.20	39.87%	1.44	2.02
IHD Only	18.06	0.72	3.99%	0.14	0.21
All	18.06	5.06	28.01%	1.01	1.68
Web Only	18.06	0.85	4.71%	0.17	0.31

Figure 4-20 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the VPP-CP rate for high-priced weekdays. The Family and Young savings are very similar, both having a big drop at the beginning of the event and a large rebound effect after the event. It appears that customers in the Mature segment may be more likely to use the PCT to set the temperature higher during the entire day, not just during the peak period, resulting in the drop during the pre-event period and a smaller rebound effect. Also note that the Family load is higher over night, possibly as a result of hotter days tending to happen in succession, so the rebound effect continues into the morning of the following day.

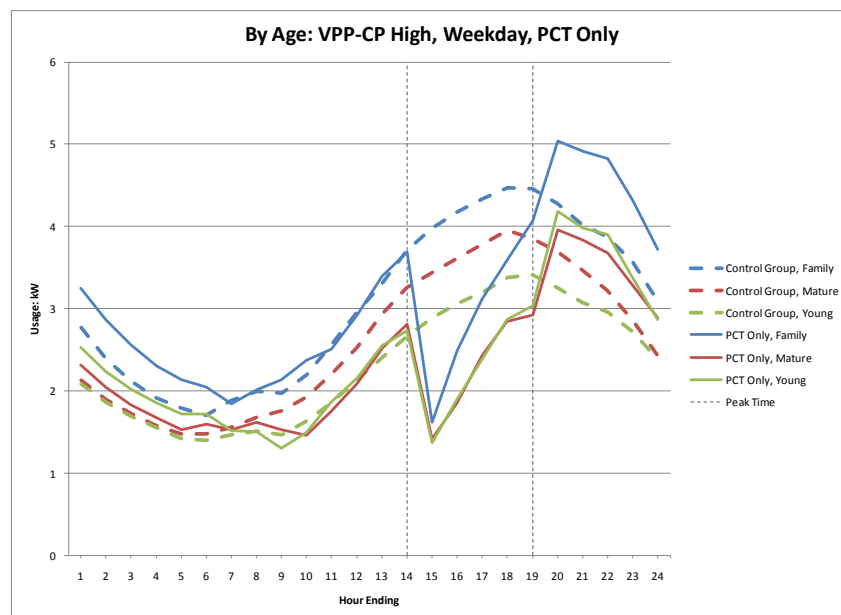


Figure 4-20 VPP-CP high-priced weekday, PCT, by age

Figure 4-21 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the VPP-CP rate for high-priced weekdays. The Family and Young load savings are similar, especially on a percentage basis. However, the

Mature load savings is much smaller in this case, in stark contrast to the TOU-CP weekday and event day above, where the Mature segment had the highest savings. We don't have an explanation for this, but it may be due to random variation in customer energy use or characteristics.

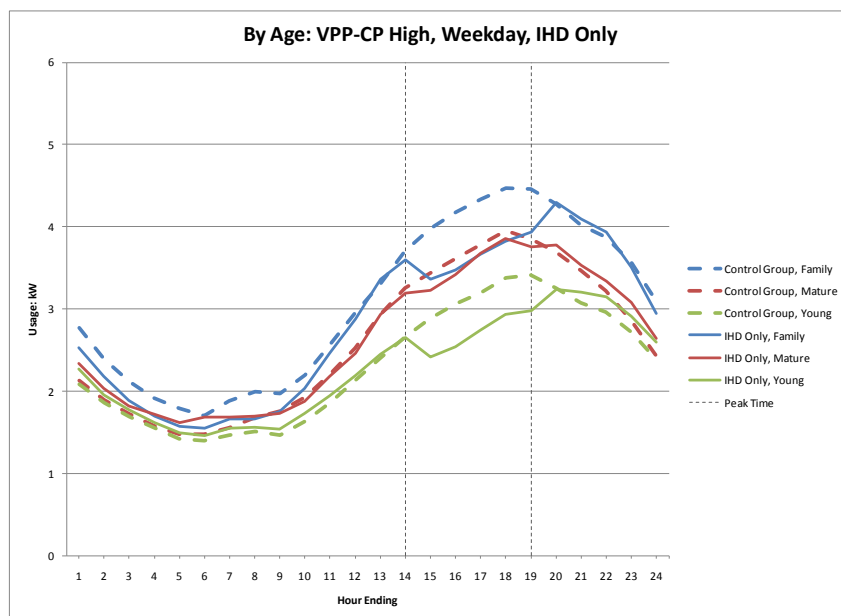


Figure 4-21 VPP-CP high-priced weekday, IHD, by age

Figure 4-22 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the VPP-CP rate for high-priced weekdays. The response here is similar to the PCT group, with all segments showing a strong drop in load at the beginning of the event, and a large rebound effect after the event. In this case, the Young segment shows more reduction leading up to the event, and a smaller rebound effect. Also as with the PCT, the rebound effect for the Family group runs into the next day, resulting in a statistically significant increase in energy use overnight.

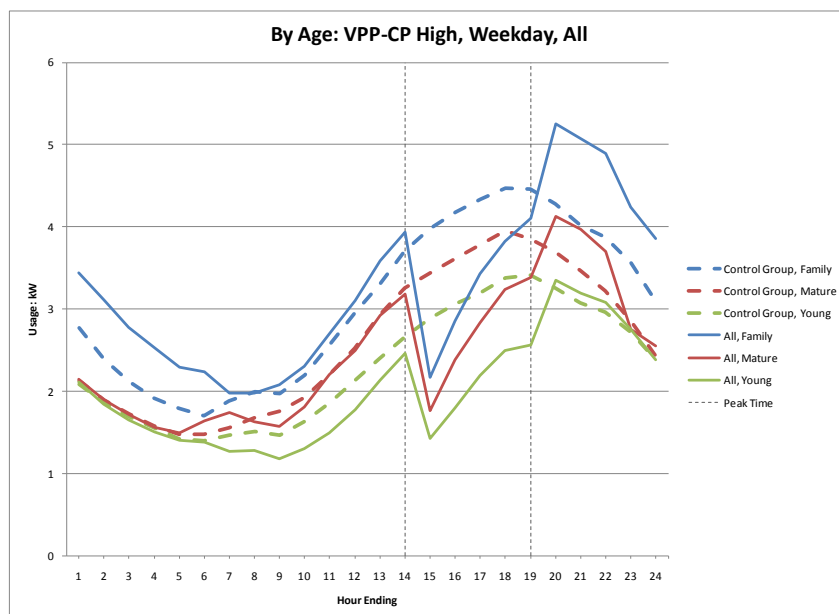


Figure 4-22 VPP-CP high-priced weekday, All Three, by age

Figure 4-23 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the VPP-CP rate for high-priced weekdays. The Family and Young segments seem to be reacting similarly, with a fairly continuous load reduction throughout the event. As with the IHD group, the Mature segment savings are smaller and not statistically significant.

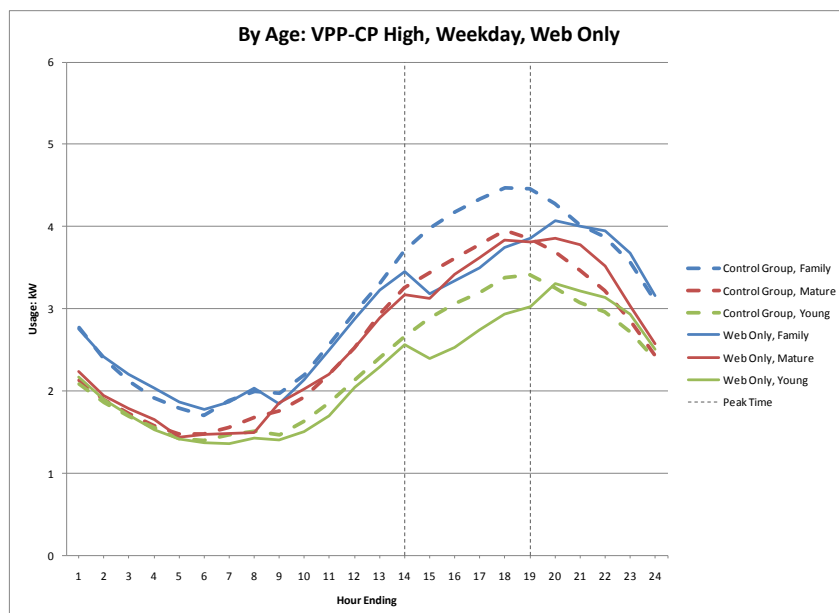


Figure 4-23 VPP-CP high-priced weekday, Web, by age

Table 4-7 below shows the savings estimates for each age group and each technology for the weekday event of August 25 for customers. The Family segment has the highest load reduction for the IHD and Web groups. The Mature segment has the highest savings for the PCT and All Three groups. The Young group has lower kW savings, but because it has a lower baseline load, the percentage savings are comparable to the Family segment.

Comparing the non-event and event days for the VPP-CP is useful as well. In all cases, the savings are higher for the high-priced weekday than for the event day. This is probably completely due to the mild weather on the event day, in contrast with the generally warmer high-priced weekdays. However, on a percentage basis, the savings on the event day are slightly higher for the IHD and web groups, probably reflecting the increased savings due to behavioral changes.

Looking across each age segment, PCT has the highest savings for the Mature segment, and the All Three group has the highest savings for the Young and Family segment.

Table 4-7 Average Customer On-Peak Savings, VPP-CP Event Weekday, by Age

	Baseline kWh Usage	kWh Savings	% Savings	Average kW Reduction	Peak kW Reduction
Young					
PCT Only	8.74	2.40	27.50%	0.48	0.65
IHD Only	8.74	1.91	21.82%	0.38	0.47
All	8.74	2.95	33.78%	0.59	0.81
Web Only	8.74	1.89	21.58%	0.38	0.44
Family					
PCT Only	11.39	2.98	26.17%	0.60	0.86
IHD Only	11.39	2.20	19.33%	0.44	0.58
All	11.39	3.46	30.40%	0.69	0.79
Web Only	11.39	2.51	22.00%	0.50	0.58
Mature					
PCT Only	9.77	4.13	42.26%	0.83	0.91
IHD Only	9.77	0.48	4.93%	0.10	0.16
All	9.77	3.60	36.85%	0.72	0.78
Web Only	9.77	0.53	5.45%	0.27	0.27

Figure 4-24 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the VPP-CP rate the weekday event. All segments respond in a similar way, with a significant load drop followed by a rebound effect after the end of the event.

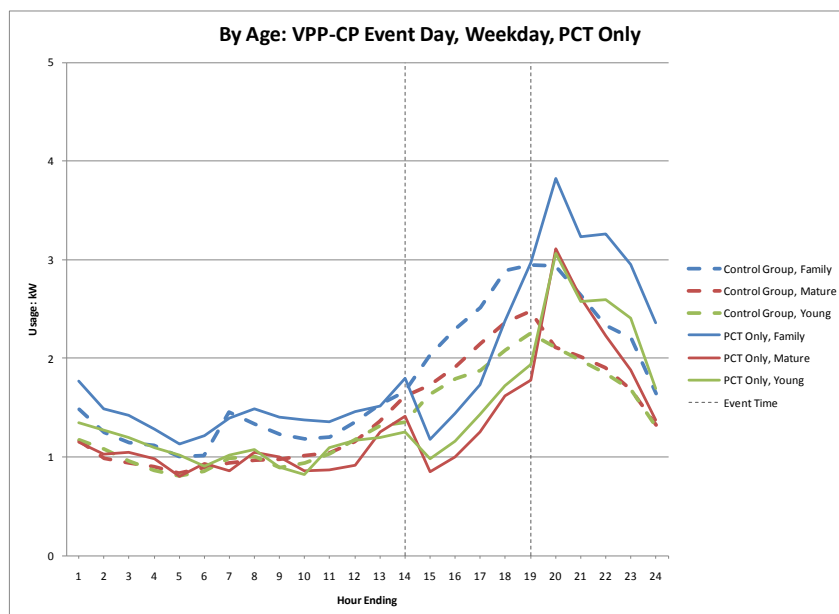


Figure 4-24 VPP-CP weekday event day, PCT, by age

Figure 4-25 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the VPP-CP rate the weekday event. As with the high-priced day, the Family and Young segments respond similarly with a fairly constant load reduction throughout the event, but the Mature group does not respond.

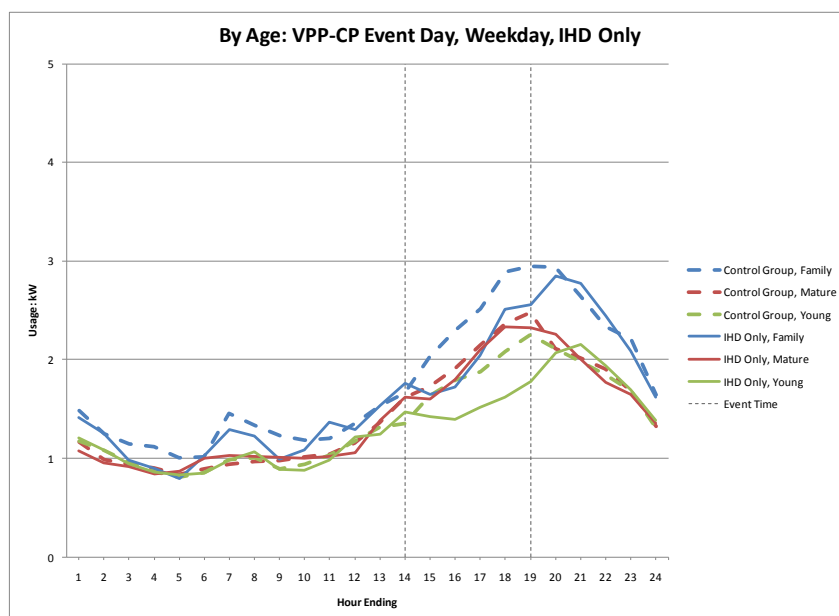


Figure 4-25 VPP-CP weekday event day, IHD, by age

Figure 4-26 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the VPP-CP rate the weekday event. The Family and Mature segments appear to be responding to the technologies in similar ways, primarily during the event period. However, as with the TOU-CP, the Young segment load shape shows a reduction in energy use for several hours before the start of the event, probably driven by behavioral changes in response to the day-ahead notification. Then, at the start of the event,

the load reduces further, probably driven by the automatic response of the PCT. All segments also have a significant rebound effect after the end of the event period.

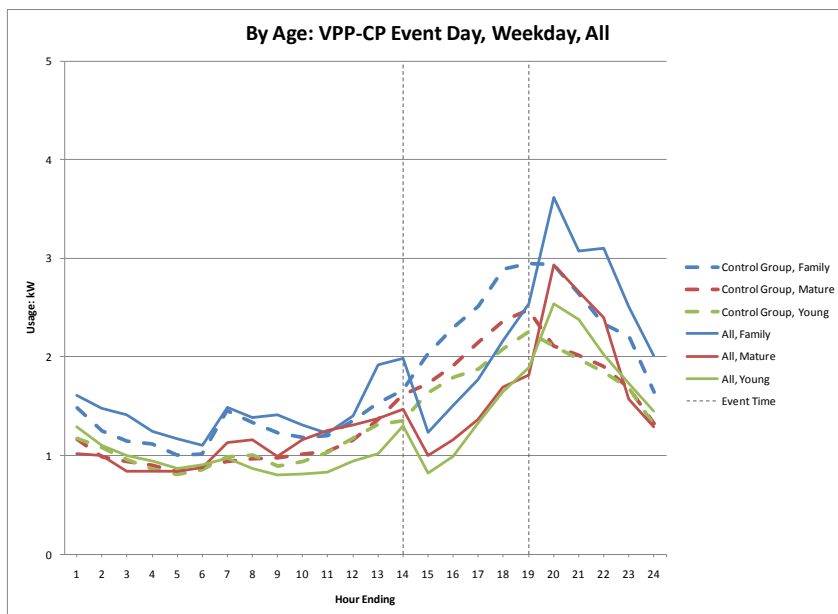


Figure 4-26 VPP-CP weekday event day, All Three, by age

Figure 4-27 below shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the VPP-CP rate the weekday event. The Family segment shape drops at the beginning of the event, and slowly comes back up at the end, indicating probable behavioral changes. The Young segment shape does the same thing, but starts earlier in the day. The Mature group does not show any significant response to the event in this case.

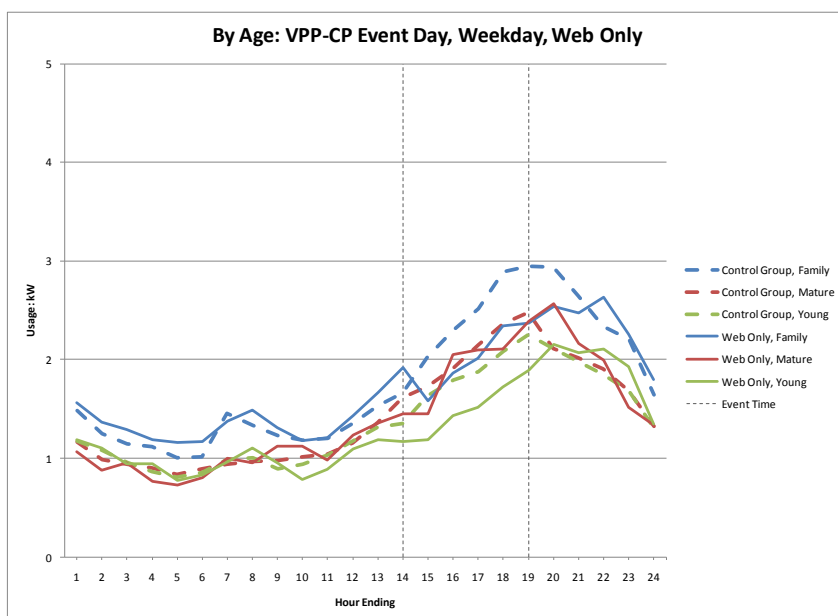


Figure 4-27 VPP-CP weekday event day, Web, by age

4.2.2 Impacts by Income Segment

The customers were split into three income categories, Low, Middle, and High, based on their PRISM Codes. Each of the rate-technology groups and the control group were split up for analysis, so that each demographic segment was compared with an appropriate control group.

4.2.2.1 Impacts by Income Segment for TOU-CP

Table 4-8 below shows the savings estimates for each income group and each technology for the average non-event weekday for customers on the TOU-CP rate. Even though the Low segment has the lowest baseline usage, they show the largest kW savings for the IHD group, as well as the highest percentage savings for all four groups. With much higher baseline consumption, the High segment does show higher kW savings for the other three technology groups. The Middle segment shows lower percentage savings and lower kW savings for all groups except the All Three group, where the kW savings are slightly higher than the Low segment.

Looking across each income segment for all segments, the PCT and All Three groups show higher savings, most likely due to the automated response of the thermostats. The Web group has the lowest savings, except for the High segment, where the Web savings exceeds the IHD savings. Curiously, the All Three group savings for the Low segment are less than the IHD savings, surprising since the All Three group customers all have an IHD. The difference is not great, so may not be statistically significant, but could also be an indication that customers with PCTs as well as IHDs may assume that the PCT will “take care of things” for them, and may pay less attention to the IHD information.

Table 4-8 Average Customer On-Peak Savings, TOU-CP Weekday, by Income

	Baseline kWh Usage	kWh Savings	% Savings	Average kW Reduction	Peak kW Reduction
Low					
PCT Only	11.63	4.89	42.01%	0.98	1.21
IHD Only	11.63	3.49	29.98%	0.70	0.75
All	11.63	3.16	27.15%	0.63	0.85
Web Only	11.63	1.02	8.73%	0.20	0.24
Middle					
PCT Only	13.21	2.95	22.34%	0.59	0.99
IHD Only	13.21	1.56	11.79%	0.31	0.36
All	13.21	3.35	25.31%	0.67	0.99
Web Only	13.21	0.72	5.44%	0.14	0.17
High					
PCT Only	17.89	5.38	30.06%	1.08	1.59
IHD Only	17.89	2.09	11.66%	0.42	0.50
All	17.89	5.32	29.72%	1.06	1.54
Web Only	17.89	3.22	18.02%	0.64	0.68

Figure 4-28 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the TOU-CP rate for non-event weekdays. All income segments show a proportional drop in load at the beginning of the event and a sizable rebound effect after the end of the event. The Low segment also shows a pretty dramatic and

statistically significant load reduction for several hours leading up to the beginning of the peak period, probably based on customer programming of the PCT. This could be an indication of higher price sensitivity of the Low segment.

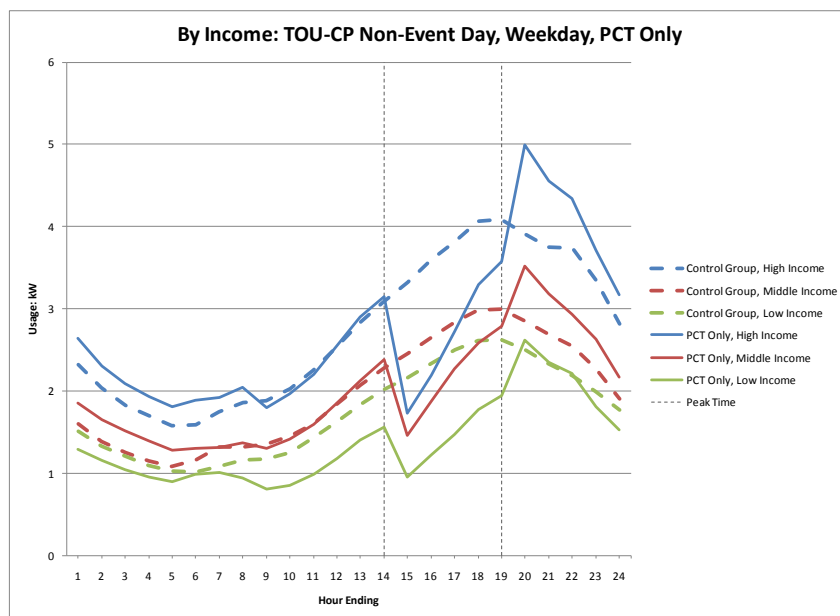


Figure 4-28 TOU-CP weekday nonevent day, PCT, by income

Figure 4-29 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the TOU-CP rate for non-event weekdays. In this case, the High and Middle segment load responses are very similar, with a consistent load reduction throughout the event, and no appreciable rebound effect. The Low segment shows a bigger drop both proportionally and in kW, including a significant drop in the hours leading up to the peak period. This could be an indication of higher price sensitivity of the Low segment.

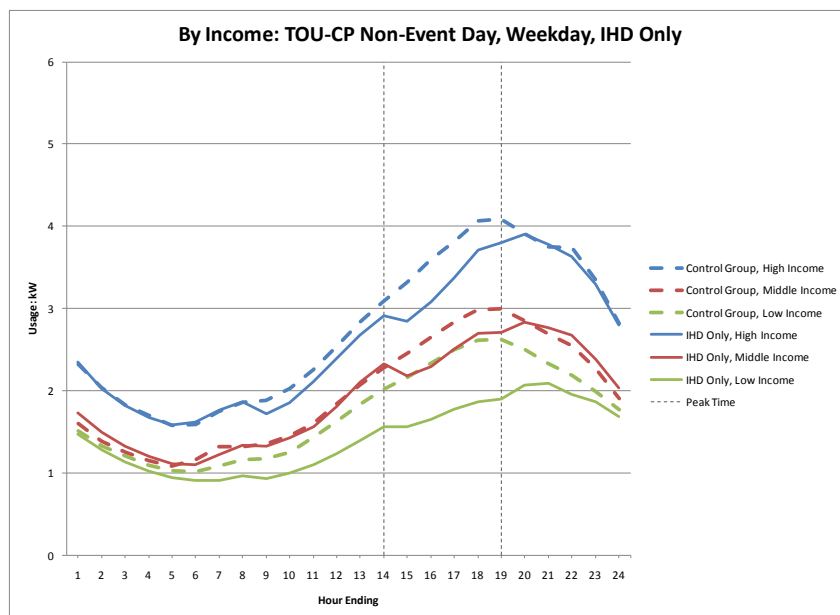


Figure 4-29 TOU-CP weekday nonevent day, IHD, by income

Figure 4-30 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the TOU-CP rate for non-event weekdays. The three income segments appear to be responding to the technologies in about the same way, reducing energy use to some extent throughout the entire day, but more during the peak period. This could be an indication of the combination of behavioral changes based on information and the automated response of the PCT.

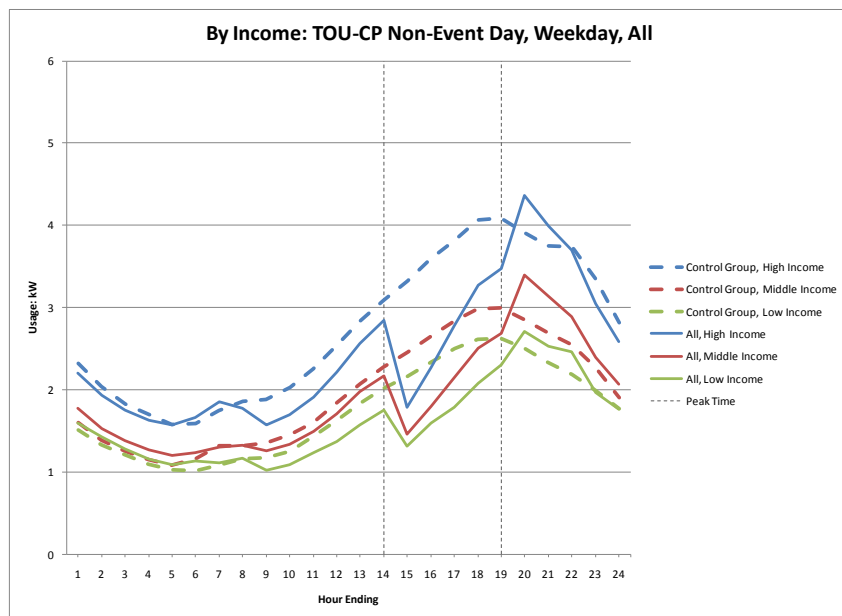


Figure 4-30 TOU-CP weekday nonevent day, All Three, by income

Figure 4-31 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the TOU-CP rate for non-event weekdays. The load responses are similar during the event for the three segments.

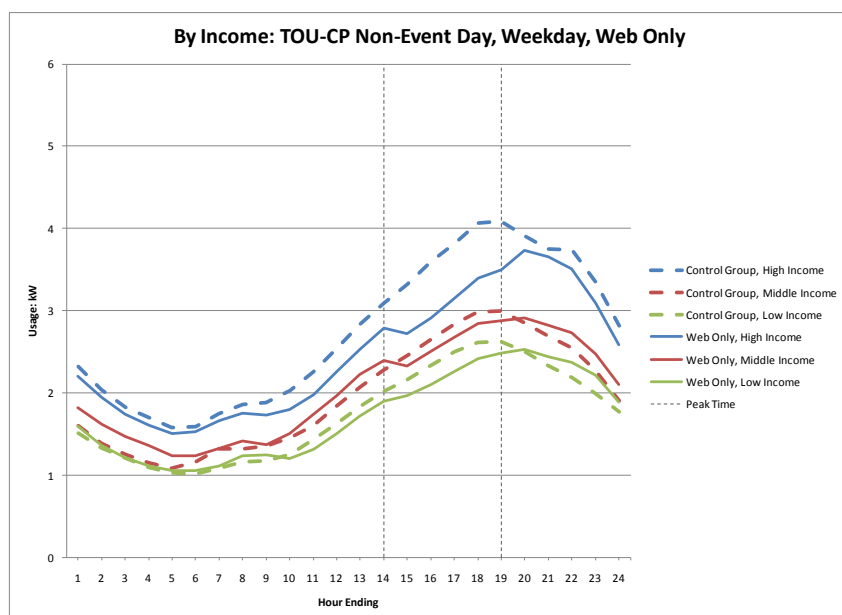


Figure 4-31 TOU-CP weekday nonevent day, Web, by income

Table 4-9 below shows the savings estimates for each income group and each technology for the weekday event of August 25 for customers on the TOU-CP rate. Even though the Low segment has the lowest baseline usage, they show the largest kW savings for the IHD group, as well as the highest percentage savings for all but the Web group. This could be further evidence of more price sensitivity for this segment. With much higher baseline consumption, the High segment does show higher kW savings for the other three technology groups. The Middle segment shows lower percentage savings and lower kW savings for all groups. The High segment shows a surprisingly high savings for the Web group, which may be indicative of higher use of and familiarity with the web in general.

Looking across each income segment, the PCT and All Three groups show higher savings for all segments, most likely due to the automated response of the thermostats. The Web group has the lowest savings, except for the High segment, where the Web savings exceeds the IHD savings. As on non-event days, the All Three group savings for the Low segment are less than the IHD savings, surprising since the All Three group customers all have an IHD. The difference may not be statistically significant, but could be an indication that customers with PCTs as well as IHDs may assume that the PCT will “take care of things” for them, and may pay less attention to the IHD information.

Table 4-9 **Average Customer On-Peak Savings, TOU-CP Event Weekday, by Income**

	Baseline kWh Usage	kWh Savings	% Savings	Average kW Reduction	Peak kW Reduction
Low					
PCT Only	7.95	3.97	49.95%	0.79	0.87
IHD Only	7.95	4.15	52.18%	0.83	0.95
All	7.95	2.94	36.92%	0.59	0.67
Web Only	7.95	1.78	22.43%	0.36	0.50
Middle					
PCT Only	9.49	3.47	36.50%	0.69	0.88
IHD Only	9.49	1.08	11.36%	0.22	0.30
All	9.49	2.88	30.39%	0.58	0.68
Web Only	9.49	1.02	10.75%	0.20	0.35
High					
PCT Only	12.38	5.23	42.27%	1.05	1.18
IHD Only	12.38	2.60	20.98%	0.52	0.64
All	12.38	4.45	35.93%	0.89	1.00
Web Only	12.38	3.74	30.19%	0.75	0.85

Figure 4-32 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the TOU-CP rate for the weekday event. All income segments show a proportional drop in load at the beginning of the event and a sizable rebound effect after the end of the event. The Low segment also shows a pretty dramatic and statistically significant load reduction for several hours leading up to the beginning of the peak period, probably based on customer programming of the PCT. This could be an indication of higher price sensitivity of the Low segment. This graph also shows the possibility that customers

are pre-cooling, ramping up their central AC before the event starts, suggested by the increase in load just before the start of the event for the Middle and High segments.

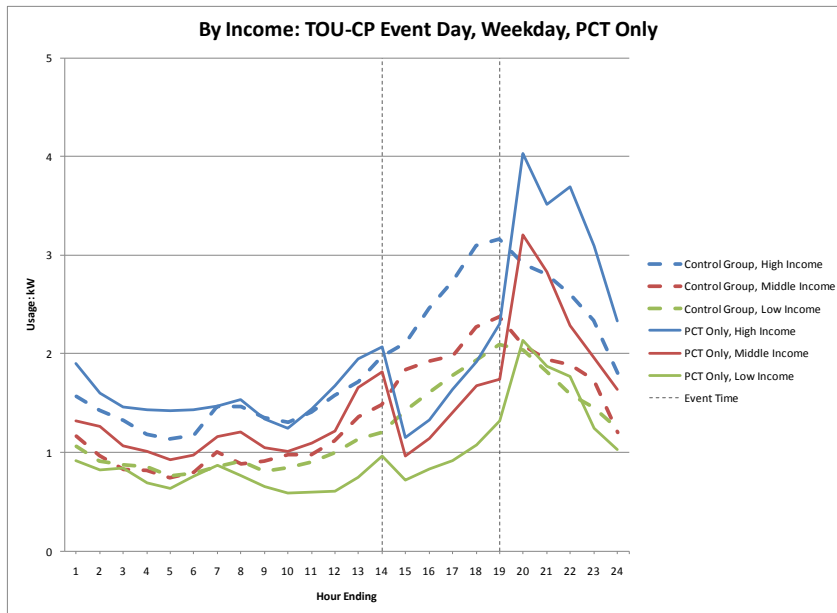


Figure 4-32 TOU-CP weekday event day, PCT, by income

Figure 4-33 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the TOU-CP rate for the weekday event. In this case, the High and Middle segment load responses are very similar, with a consistent load reduction throughout the event, and no appreciable rebound effect, with the High segment showing more savings. The Low segment shows a bigger drop both proportionally and in kW, including a significant drop in the hours leading up to the peak period. This could be an indication of higher price sensitivity of the Low segment.

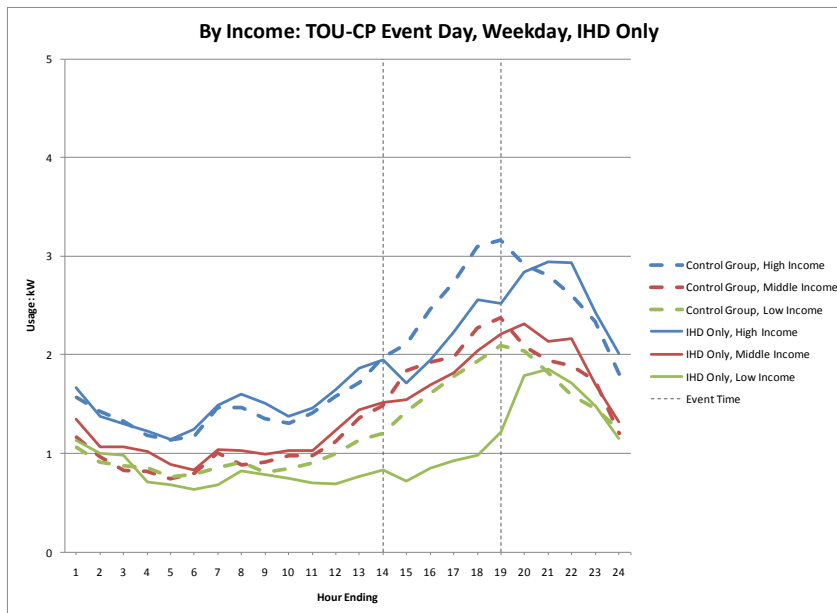


Figure 4-33 TOU-CP weekday event day, IHD, by income

Figure 4-34 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the TOU-CP rate for the weekday event. The three income segments appear to be responding to the technologies in similar ways, with a big load drop at the beginning of the event period, and a sizable rebound after. The Low segment shows less of a rebound.

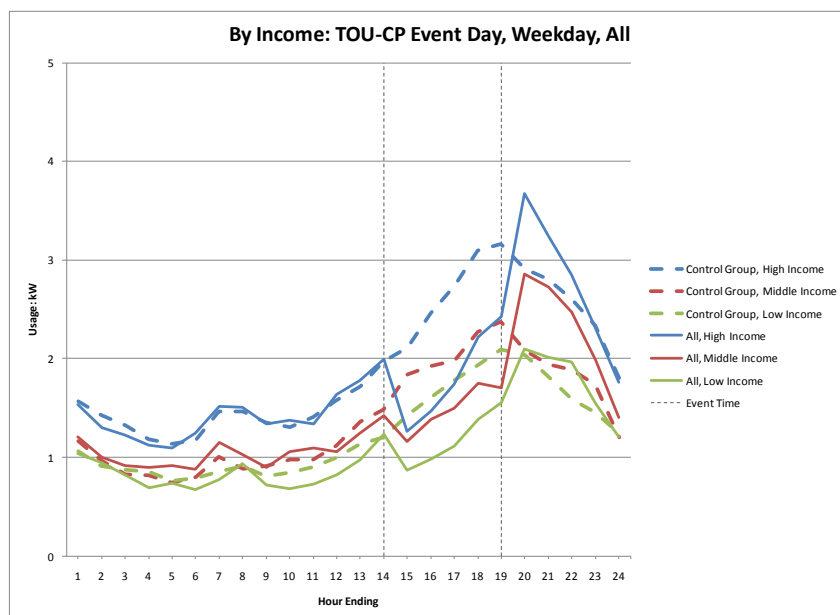


Figure 4-34 TOU-CP weekday event day, All Three, by income

Figure 4-35 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the TOU-CP rate for the weekday event. The three income segments appear to be responding similarly during the event period, with most of the load reduction probably due to behavioral changes, given the lack of much of a rebound effect for any of the segments. The Middle segment shows the smallest load reduction.

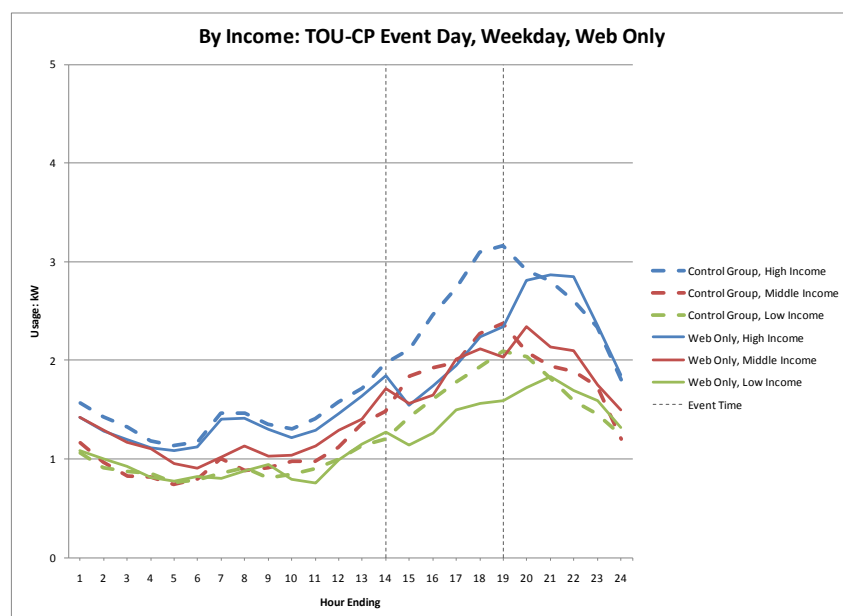


Figure 4-35 TOU-CP weekday event day, Web, by income

4.2.2.2 Impacts by Income Segment for VPP-CP

Table 4-10 below shows the savings estimates for each income group and each technology for the average non-event weekday for customers on the VPP-CP rate. Even though the Low segment has the lowest baseline usage, the kW savings for the IHD group is about the same as the High segment, and twice the Middle segment. With much higher baseline consumption, the High segment does show the highest kW savings for all technology groups.

Looking across each income segment for all segments, the PCT and All Three groups show higher savings in each segment, most likely due to the automated response of the thermostats. The Web group has the lowest savings for the Middle group, but higher savings than the IHD for the Low segment. This low savings for the IHD group for the Low segment is not statistically significant, and is difficult to interpret, since for the TOU-CP rate, the savings were much higher.

Table 4-10 Average Customer On-Peak Savings, VPP-CP High-Priced Weekday, by Income

	Baseline kWh Usage	kWh Savings	% Savings	Average kW Reduction	Peak kW Reduction
Low					
PCT Only	14.85	7.10	47.84%	1.42	1.95
IHD Only	14.85	0.75	5.07%	0.15	0.20
All	14.85	2.96	19.93%	0.59	1.14
Web Only	14.85	1.88	12.65%	0.38	0.53
Middle					
PCT Only	16.88	3.48	20.63%	0.70	1.65
IHD Only	16.88	2.33	13.82%	0.47	0.57
All	16.88	5.06	29.99%	1.01	1.61
Web Only	16.88	1.63	9.68%	0.33	0.38

High					
PCT Only	21.87	7.14	32.63%	1.43	2.15
IHD Only	21.87	3.02	13.83%	0.60	0.63
All	21.87	8.02	36.67%	1.60	2.24
Web Only	21.87	3.03	13.84%	0.61	0.69

Figure 4-36 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the VPP-CP rate for high-priced weekdays. All income segments show a proportional drop in load at the beginning of the event and a sizable rebound effect after the end of the event. The Low segment also shows a pretty dramatic and statistically significant load reduction for several hours leading up to the beginning of the peak period, probably based on customer programming of the PCT. This could be an indication of higher price sensitivity of the Low segment.

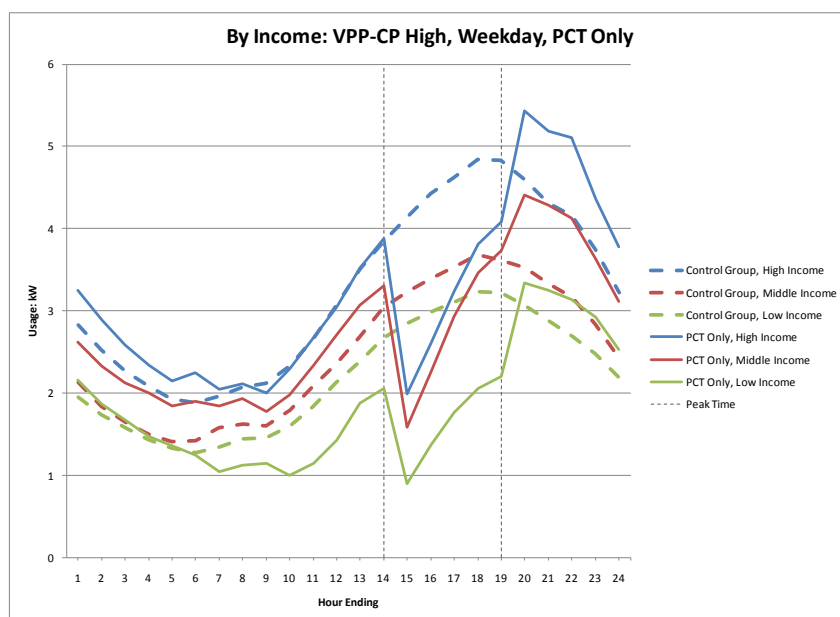


Figure 4-36 VPP-CP high-priced weekday, PCT, by income

Figure 4-37 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group for the VPP-CP rate for high-priced weekdays. The Middle and High segment Low load savings are similar, showing a consistent load reduction throughout the peak period. Surprisingly, however, the Low segment load savings is much smaller in this case, in contrast to the TOU-CP weekday and event day above. We don't have an explanation for this, but it may be due to random variation in customer energy use or characteristics.

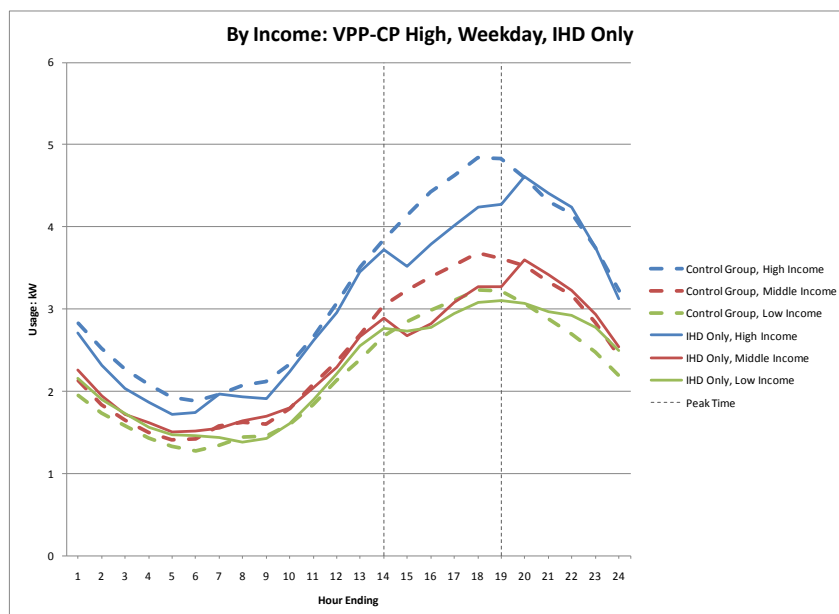


Figure 4-37 VPP-CP high-priced weekday, IHD, by income

Figure 4-38 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the VPP-CP rate for high-priced weekdays. The response here is similar to the PCT group, with all segments showing a strong drop in load at the beginning of the event, and a large rebound effect after the event. However, in this case, the Low segment does not show load reduction leading up to the event as it did above.

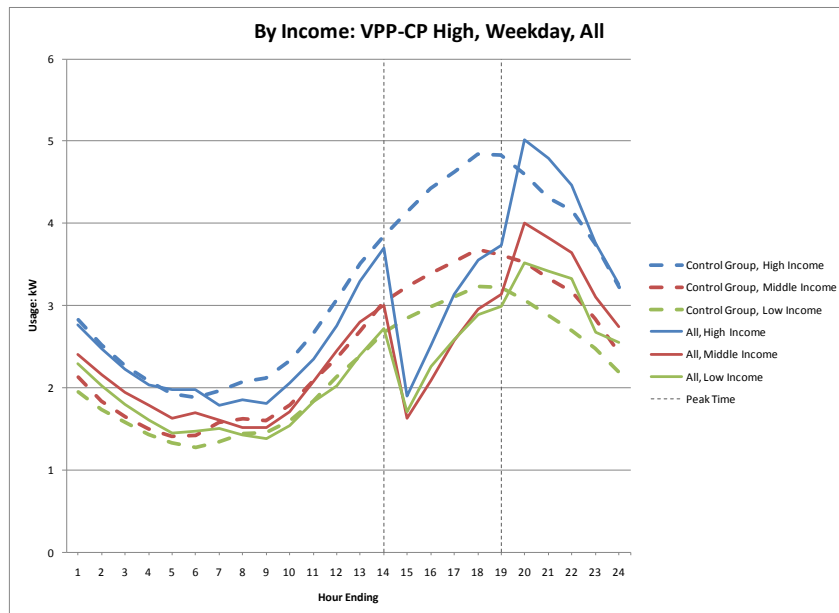


Figure 4-38 VPP-CP high-priced weekday, All Three, by income

Figure 4-39 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the VPP-CP rate for high-priced weekdays. The three income segments show similar load reduction patterns, with a fairly constant reduction throughout the peak period.

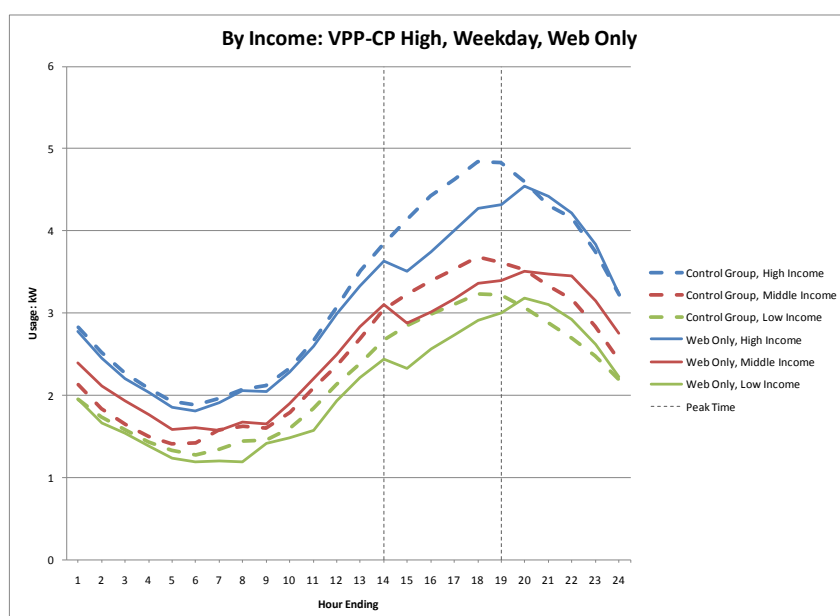


Figure 4-39 VPP-CP high-priced weekday, Web, by income

Table 4-11 below shows the savings estimates for each income group and each technology for the weekday event of August 25 for customers on the VPP-CP rate. The results are similar to the high-priced day, but with slightly higher savings in most cases. Given that the event-day price is the same as the high price, this is what we would expect. Again, the Low segment has the greatest kW and percentage savings in the PCT group, with the highest percentage savings of any group or segment at over 55%. The All Three group is the highest load reduction for both the Middle and High segments.

Table 4-11 Average Customer On-Peak Savings, VPP-CP Event Weekday, by Income

	Baseline kWh Usage	kWh Savings	% Savings	Average kW Reduction	Peak kW Reduction
Low					
PCT Only	7.95	4.42	55.57%	0.88	1.07
IHD Only	7.95	0.93	11.72%	0.19	0.34
All	7.95	1.23	15.50%	0.25	0.50
Web Only	7.95	1.34	16.81%	0.27	0.43
Middle					
PCT Only	9.49	1.58	16.66%	0.32	0.67
IHD Only	9.49	1.00	10.51%	0.20	0.47
All	9.49	4.13	43.47%	0.83	1.04
Web Only	9.49	0.98	10.34%	0.20	0.42
High					
PCT Only	12.38	3.32	26.81%	0.66	0.81
IHD Only	12.38	2.57	20.74%	0.51	0.73
All	12.38	5.03	40.64%	1.01	1.08

Web Only	12.38	2.38	19.26%	0.48	0.68
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Figure 4-40 shows the three segment participant load shapes along with their corresponding control group load shapes for the PCT group for the VPP-CP rate the weekday event. All segments respond in a similar way, with a significant load drop followed by a rebound effect after the end of the event. The Low segment shows some load reduction in the several hours before the event.

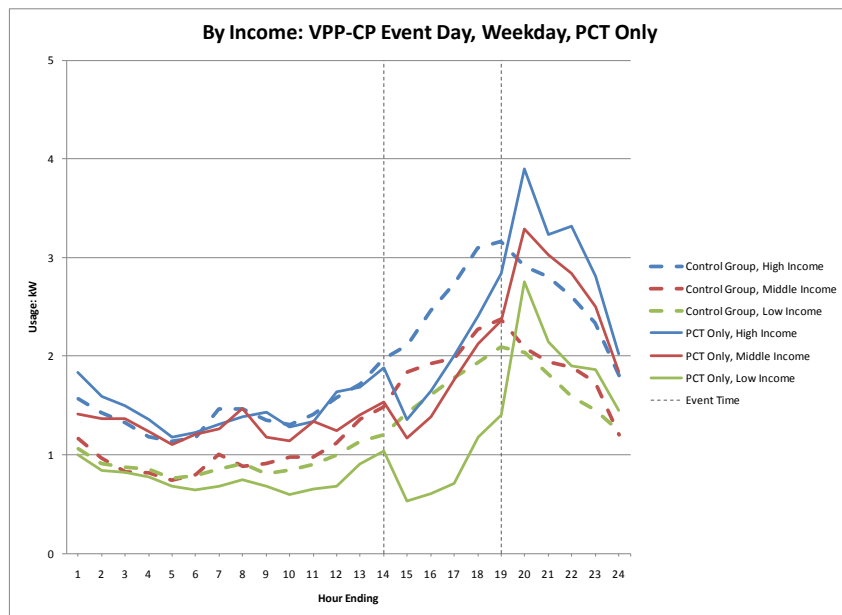


Figure 4-40 VPP-CP weekday event day, PCT, by income

Figure 4-41 shows the three segment participant load shapes along with their corresponding control group load shapes for the IHD group. The High segment shows the biggest load reduction, with the Middle and Low segments showing less.

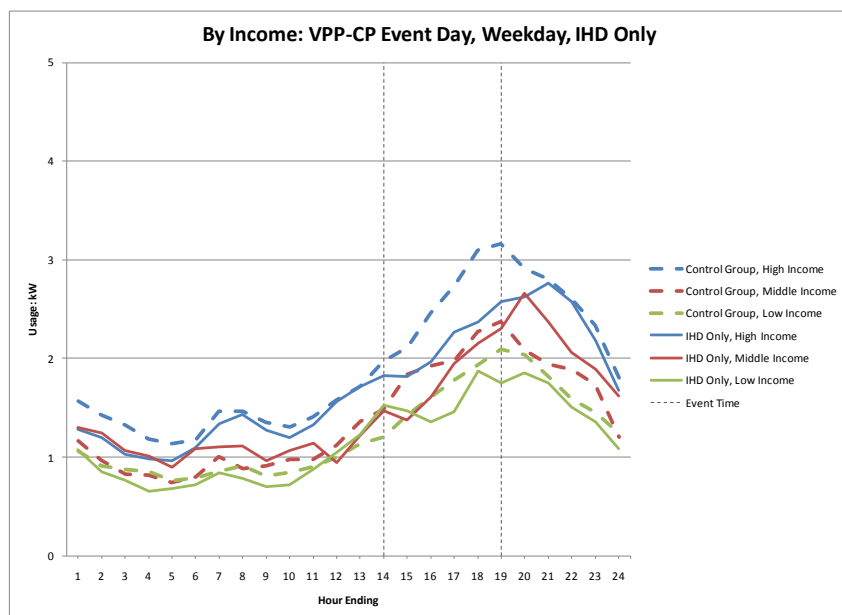


Figure 4-41 VPP-CP weekday event day, IHD, by income

Figure 4-42 shows the three segment participant load shapes along with their corresponding control group load shapes for the All Three group for the VPP-CP rate the weekday event. The three segments show about the same load reduction pattern, but the Low segment has much smaller savings than the other two segments.

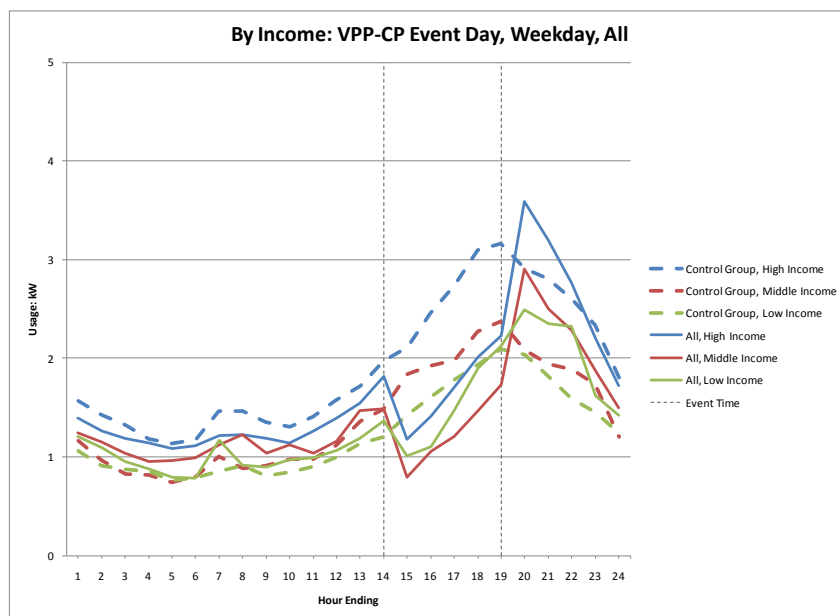


Figure 4-42 VPP-CP weekday event day, All Three, by income

Figure 4-43 shows the three segment participant load shapes along with their corresponding control group load shapes for the Web group for the VPP-CP rate the weekday event. The three segments show similar load reduction patterns, with the High segment showing more savings than the other two.

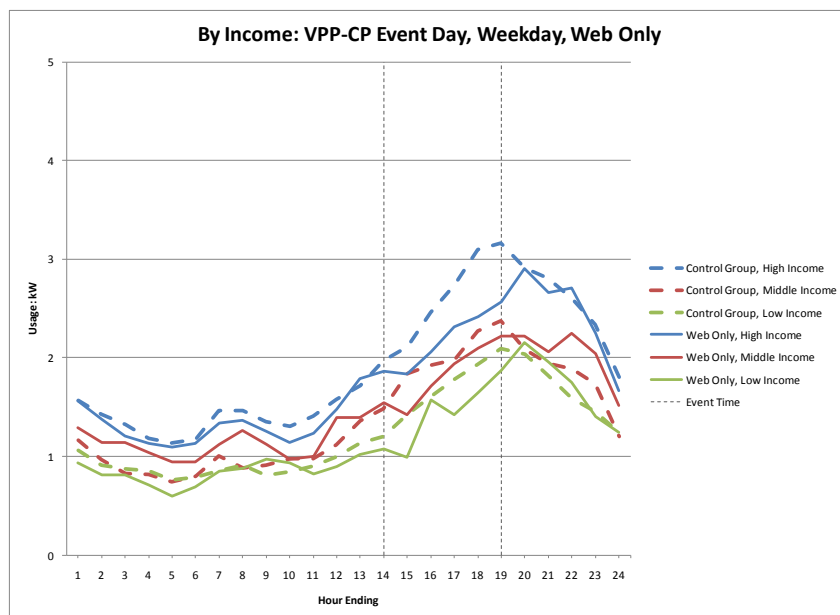


Figure 4-43 VPP-CP weekday event day, Web, by income

SUMMARY AND RECOMMENDATIONS

5.1 SUMMARY

The specific preliminary results of the Smart Study TOGETHER are listed below.

- In general, the automated response of the PCT and All Three groups reduce load more than the information provided through the IHD and Web Portal. However, the IHD and Web Portal load reductions are more constant throughout the peak period, whereas the PCT and All Three groups tend to have a load reduction spike at the beginning, and savings that decay later in the period. There was also usually a significant rebound effect after the event for the PCT and All Three groups.
- There is very little change in weekend loads for either rate, either up in response to lower prices or down out of habit.
- There is no statistically significant change in loads on low-priced days for VPP customers, but it does appear that some customers are programming their thermostats in conventional ways to reduce energy use while they are away from the home.
- The TOU-CP shows significant load reductions for all technology groups on both non-event weekdays and the weekday event.
- The VPP-CP rate shows load reductions that correspond to the price level on weekdays – there is statistically significant load reduction on days when prices are standard, medium, and high, and the load reduction increases as the price increases.
- The one weekend event was on a late summer day, and as a result, the savings were smaller but still statistically significant. Because there was not much cooling load, the PCT and All Three groups showed less savings, particularly for the VPP-CP.
- The one weekday event was on a mild day as well. The kW savings for the TOU-CP were comparable to the average weekday, but because the load was lower, the percentage savings were higher. The behavior of the VPP-CP customers was similar to their behavior on a high-priced day (not surprising, since the high price is the same as the critical price during an event), but with less load reduction since the load for the day was lower because of the temperature.
- The PCT groups often show more savings than the All Three group, but this is likely due to the fact that the PCT group included only those with central AC, and the All Three group included customers both with and without central AC.
- In several cases, the All Three group showed both overall load reductions throughout the day and further reductions in the peak period. This suggests that the information technologies (IHD and Web) are prompting behavioral changes in addition to the automated response of the PCT.

5.1.1 Age Segment Conclusions

The preliminary results related to the Age segments are summarized below.

- The Family age segment has the highest average baseline usage, and generally has higher load reductions, particularly for the PCT and All Three groups.
- In several cases, the Mature and Young groups showed better load response than the Family group to the information provided by the IHD.

- The Mature customers on the TOU-CP rate seemed to respond to the IHD rather dramatically, but this was not the case for the Mature customers on the VPP-CP rate.
- The PCT and All Three groups generally had higher savings for each of the age segments, consistent with the trend for the combined population.

5.1.2 Income Segment Conclusions

The preliminary results related to the Income segments are summarized below.

- The High income segment has the highest average baseline usage, and generally has higher load reductions.
- The Low income segment shows higher percentage savings in many cases, and in some cases higher kW savings than the generally higher-consuming Middle and High income segments. This may be a result of Low income customers being more price sensitive and taking more actions to reduce load.
- The PCT and All Three groups in the Low income segment appear to have load reductions throughout the day, including several hours before the event. Since these are off-peak periods, this is not price response, but may be due to the PCTs replacing manual thermostats, then being used to reduce load when the home is unoccupied. It could also be due to higher energy awareness.
- In some cases, the High income segment shows more load reduction for the Web Portal group, which may be due to easier access to the web or better familiarity.

5.2 RECOMMENDATIONS FOR PHASE II

Going forward, we have the following recommendations for the implementation of Phase II. In some cases, we may modify the analysis of Phase I data to reflect these recommendations.

- Split the control group for the analysis between those with and those without central AC. This will allow for a more appropriate comparison of the PCT group with the other technology groups.
- In the recruiting, use a more presumptive approach for participants. Once the customer completes the survey, we should describe what they will be getting and set things up based on the assumption that they will be participating – don't ask them if they are still interested.
- Adjust the marketing to reflect the expected recruiting rates by demographic segment. For those demographic segments that were difficult to enroll in the first phase, market to everyone. For those that were filled early, randomly subdivide the population and only market to a subset that is inversely proportional to the recruiting rate from phase I.
- Consider not using the secondary assignments for the PCT and Web Portal groups. If a customer is preassigned to the PCT group and does not have central AC, do not include them in the study. We can put them on the rate and assign them to the Web Portal, but their data will not be analyzed as part of the analysis. This will eliminate a small bias in the other technology groups resulting from the inclusion of slightly more customers without central AC.
- Call more events across a wider variety of days. Develop a plan to call events so that they are called on with a wide range of temperatures.

APPENDIX A – ALGORITHM FOR DETERMINING ACTUAL ASSIGNMENTS

APPENDIX B – INDIVIDUAL LOAD SHAPES

APPENDIX C – INDIVIDUAL LOAD SHAPES BY AGE SEGMENTS

APPENDIX D – INDIVIDUAL LOAD SHAPES BY INCOME SEGMENTS

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Global Energy Partners
500 Ygnacio Valley Road, Suite 450
Walnut Creek, CA 94596

P: 925.482.2000
F: 925.284.3147
E: gephq@gepllc.com

